NOTE: This draft, dated 14 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042A(SH)

SUPERSEDING
MIL-STD-2042(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS

AMSC N/A AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies (fiber optic cabling and associated components) on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

5. Considering the magnitude of this standard, along with the changing requirements imposed on the fiber optic cable topology, it is inevitable that changes will be required to update these methods. Therefore, when the need for change is recognized, comments should be forwarded to Naval Sea Systems Command (NAVSEA) 03K12. Revisions to this standard will be by issuance of change pages.

CONTENTS

1. SCOPE

1.1 Scope. This standard provides detailed methods for the installation and test of fiber optic cabling and associated components (see 3.1) on Naval surface ships and submarines.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. Where there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Standards. The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

DOD-STD-2003 - Electric Plant Installation, Standard Methods for Surface Ships and Submarines.

MIL-STD-2042-1 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cables) (Part 1 of 6 Parts).

MIL-STD-2042-2 - Fiber Optic Cable Topology Installation, Standard Methods For Naval Ships (Equipment) (Part 2 of 6 Parts).

MIL-STD-2042-3 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cable Penetrations) (Part 3 of 6 Parts).

MIL-STD-2042-4 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cableways) (Part 4 of 6 Parts).

MIL-STD-2042-5 - Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Connectors and Interconnections) (Part 5 of 6 Parts).

MIL-STD-2042-6 - Fiber Optic Cable Topology Installation, Standard Methods For Naval Ships (Tests) (Part 6 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA 19111-5094.)

2.2 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, outlets, trunk and local cables and the connectors and splices used to interconnect trunk and local cables.

3.2 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.3 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.4 End user equipment. End user equipment refers to any cabinet, case, panel, or device, that contains components that are either the origin or destination of an optical signal.

3.5 Outlet. An outlet is a small termination box used to break out a local cable from an interconnection box to one or more equipments within a compartment.

4. GENERAL REQUIREMENTS

4.1 Organization. This standard is comprised of seven different parts, each of which is a separate publication with a unique identification number. This organization provides maximum flexibility in using, referencing and revising the standard. The complete standard consists of the basic standard and six numbered parts as follows:

MIL NUMBER	TITLE
MIL-STD-2042	Fiber Optic Cable Topology Installation Standard Methods For Naval Ships.
MIL-STD-2042-1	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Cables)(Part 1 of 6 Parts).
MIL-STD-2042-2	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Equipment)(Part 2 of 6 Parts).
MIL-STD-2042-3	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Cable Penetrations)(Part 3 of 6 Parts).
MIL-STD-2042-4	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Cableways)(Part 4 of 6 Parts).
MIL-STD-2042-5	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Connectors and Interconnections)(Part 5 of 6 Parts).
MIL-STD-2042-6	Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

4.2 Arrangement and contents. Each numbered part of this standard contains a series of standard installation methods. Methods providing similar functions are grouped together for ease of useability and referencing as follows:

MIL-STD-2042 Part Number	Functional group	Function
1 (Cables)	A	Cable end-sealing
	B	Cable jacket repair
2 (Equipment)	A	Cable entrance to equipment via nylon stuffing tubes
	B	Cable entrance to equipment via MCP
	C	Cable and buffered fiber forming and shaping
	D	Splice assembly and alignment
3 (Penetrations)	A	Cable penetrations via metal stuffing tubes
	B	Cable penetrations via Multicable Penetrator (MCP)
4 (Cableways)		Methods in DOD-STD-2003 referenced
5 (Connectors and Inter-connections)	A	Multiple terminus connector installation
	B	Single terminus connector installation
	C	Mechanical splice ferrule installation
6 (Tests)	A	Visual inspection of fiber optic components
	B	Cable attenuation test
	C	Cable assembly link loss test
	D	Cable continuity test
	E	Cable topology end-to-end attenuation test
	F	Test jumper cable selection test
	G	Heavy duty connector mechanical pull test

5. DETAILED REQUIREMENTS (Not applicable)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The standard methods for installation and test of the fiber optic cable topology depicted in Parts 1 through 6 of this standard are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. In the case of conversion or alteration, the degree of applicability of these criteria shall be specified by the activity preparing instructions for the work.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1).

6.3 Subject term (key word) listing.

Cable
Organization
Arrangement and content

Preparing activity:
NAVY - SH

(Project GDRQ-NXXX)

NOTE: This draft, dated 15 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-1A(SH)

SUPERSEDING
MIL-STD-2042-1(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CABLES)

(PART 1 OF 6 PARTS)

AMSC N/A AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies (fiber optic cabling and associated components) on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

CONTENTS

CONTENTS

1. SCOPE

1.1 Purpose. This standard provides detailed methods for fiber optic cable selection, handling, marking, and repair.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. Where there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-A-2877	- Aluminum Alloy Tape.
MIL-I-23053/15	- Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked.
MIL-S-24623	- Splice, Fiber Optic Cable, General Specification for (Metric).
MIL-C-28876	- Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini, General Specification for.
MIL-F-49291	- Fiber, Optical, (Metric) General Specification for.
MIL-I-81765/1	- Insulating Components, Molded, Electrical, Heat Shrinkable, Polyolefin, Crosslinked, Semi-rigid and Flexible.
MIL-C-83522	- Connectors, Fiber Optic, Fixed Single Terminus, General Specification for.
MIL-C-85045	- Cables, Fiber Optic,(Metric) General Specification for.

STANDARDS

MILITARY

MIL-STD-2189	- Design Methods For Naval Shipboard Systems.
Section 305-1	- Designation and Marking of Electrical System.
MIL-STD-2042-2	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Equipment)(Part 2 of 6 Parts).
MIL-STD-2042-3	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cable Penetrations)(Part 3 of 6 Parts).
MIL-STD-2042-4	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cableways)(Part 4 of 6 Parts).
MIL-STD-2042-5	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Connectors and Interconnections)(Part 5 of 6 Parts).
MIL-STD-2042-6	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of

the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, outlets, trunk and local cables and the connectors and splices used to interconnect the trunk and local cables.

3.3 Authorized approval. Authorized approval is written approval from the cognizant Government activity.

3.4 Installing activity. An installing activity is any military or commercial organization involved with the installation of fiber optic cable topologies aboard Naval ships.

3.5 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.6 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment, or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.7 Minimum bend diameter. The minimum bend diameter of a fiber optic cable (and OFCC, see 3.20) is the diameter at which the cable can be bent without degrading optical performance. The short term bend diameter applies during handling and installing; the long term bend diameter applies to the completed installation.

3.8 End user equipment. End user equipment refers to any cabinet, case, panel, or device that contains components that are either the origin or destination of an optical signal.

3.9 Allocated and used fiber. An allocated and used fiber is a fiber that is designated and required for use for a particular system, and is being used to transmit information. Allocated and used fibers include fibers used for normal channels, fibers for alternate channels, and fibers for non redundant channels.

3.10 Allocated and not used fiber. An allocated and not used fiber is a fiber that is designated for use for a particular system, but is not being used to transmit information. Allocated and not used fibers include fibers allocated as system spare fibers, system growth fibers, and system redundant fibers.

3.11 Unallocated fiber. An unallocated fiber is a fiber that is not designated for use for any system, but is required as part of the cabling. Unallocated fibers include spare fibers and growth fibers.

3.12 Unused fiber. An unused fiber is a fiber that is not designated for use for any system and not required as part of the cabling. Unused fibers occur within the fiber optic cable topology when the required systems fibers are less than the number of fibers available within a standard cable size.

3.13 Normal channel. A normal channel is an allocated and used active link between system equipment that has a designated active backup link.

3.14 Alternate channel. An alternate channel is the allocated and used active backup link for a normal channel.

3.15 Non redundant channel (NRC). A non redundant channel is any allocated and used active link that has no system required backup link.

3.16 Cable repair. Cable repair refers to restoration of only the outermost cable jacket.

3.17 Cable splicing. Cable splicing, as used in this standard, refers to the repair of damaged fiber optic cables by reconnecting severed fibers and providing an environmental enclosure at the spliced region.

3.18 System specific cables. System specific cables are those fiber optic cables that connect end user equipments and do not interface with a fiber optic cable plant (see 3.19).

3.19 Fiber optic cable plant. The fiber optic cable plant is the portion of the fiber optic topology made up of the trunk cables and interconnection boxes.

3.20 Optical fiber cable component (OFCC). An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket.

3.21 Outlet. An outlet is a small termination box used to break out a local cable from an interconnection box to one or more equipments within a compartment or area.

3.22 Spare fiber. A fiber that is not allocated for use by any system, but is reserved for use as a maintenance spare in the case of damage to an allocated fiber within the cable. A system spare fiber is an allocated and not used fiber designated for a particular system.

4. GENERAL REQUIREMENTS

4.1 Cables. Fiber optic cables for Naval shipboard application shall be in accordance with MIL-C-85045.

4.1.1 Cable selection. Cables selected shall be those referenced in ship specifications, ship installation drawings, contract drawings, or other approved drawings as specified in the contract or by the cognizant Government activity. Substitute cables shall not be used without authorized approval (see 3.3). In those instances where the installing activity (see 3.4) is responsible for determining the correct type and size cable for a specific application, the fiber optic cables shall be selected in accordance with MIL-C-85045. Fibers shall be in accordance with MIL-F-49291, either type SU (single mode) or type MM (multimode) as required by the system.

4.1.2 Spare optical fibers. The number of spare optical fibers shall be in accordance with the ship specification and system drawings. Spare fibers are located in both trunk cables and local cables which penetrate bulkheads or decks (see 3.5 and 3.6).

4.1.3 Cable storage and handling.

4.1.3.1 Cable storage. Cables shall be stored in a dry place protected from the weather and limited to a temperature range of not less than -40 degrees Celsius (°C) [-40 degrees Fahrenheit (°F)] nor greater than +70°C (+158°F). A cable that has been in storage for less than one year may be installed if a visual inspection of the cable shows no mechanical damage that would impair the watertight integrity of the cable's outer sheath or the integrity of the optical fiber cable components (OFCC's). A cable that has been in storage for one year or longer may be installed if it passes the visual inspection in accordance with Method 6A1 in Part 6 of this standard, and if the attenuation measured in accordance with Method 6B1 in Part 6 of this standard is less than the value specified. Cables shall be stored on reels with minimum diameters of 24 times the cable outside diameter or coiled so that the bend diameter shall be not less than 24 times the cable outside diameter. Bare ends of stored cables shall be sealed against moisture using heat shrink end caps as specified herein (see 5.1). Terminated cables shall be sealed against moisture using connector dust covers (for multiple terminus connectors), plastic caps or heat shrink end caps as specified herein (see 5.1).

4.1.3.2 Cable handling. During handling, the cable shall be protected from crushing, kinks, twists, and bends that violate the minimum short term bend diameter of eight times the cable outside diameter (see 3.7). Additional caution shall be used when handling cables in ambient temperatures at or below 36°F (2°C) (see Part 4 of this standard).

4.1.4 Cables entering interconnection boxes or other equipment. Cables shall enter interconnection boxes or other equipment in accordance with the methods in Part 2 of this standard.

4.1.5 Cable penetrations. The passing of cables through decks and bulkheads shall be in accordance with the methods in Part 3 of this standard.

4.1.6 Cable installation and protection. Fiber optic cables shall be installed in the cableways and protected in accordance with Part 4 of this standard.

4.1.7 Cable connections. Cable connections to equipment external to the fiber optic cable topology, such as end user equipment (see 3.8), shall be made with multiple terminus heavy duty connectors in accordance with MIL-C-28876, or single terminus light duty connectors in accordance with MIL-C-83522, or splices in accordance with MIL-S-24623 as specified in Part 5 of this standard. Light duty connectors and splices used for external equipment connections shall be housed within that equipment. Light duty connectors and splices used for cable interconnections internal to the fiber optic cable topology shall be housed within interconnection boxes, as specified in Part 2 of this standard.

4.1.7.1 Termination of fibers. There are four categories of fibers:

a. Allocated and used (see 3.9).

b. Allocated and not used (see 3.10)

c. Unallocated (see 3.11).

d. Unused (see 3.12).

The quantity of the first three categories shall be as specified in the ship specification and on the system drawings.

4.1.7.1.1 Allocated and used fibers. The allocated and used trunk and local cable fibers are normal channel fibers (see 3.13), alternate channel fibers (see 3.14), and non-redundant channel (NRC) fibers (see 3.15). These fibers shall be terminated in accordance with the system drawings.

4.1.7.1.2 Allocated and not used fibers. The allocated and not used fibers are system required spares and system required redundant fibers. These fibers shall be terminated in accordance with the system or fiber optic cable topology drawings. If there are no system requirements, either the splice or single terminus connector may be installed as required to meet the system link loss budget.

4.1.7.1.3 Unallocated fibers. The unallocated trunk cable fibers are fiber optic cable topology maintenance spare fibers and growth fibers for unidentified future systems. Only those local cables that penetrate decks and bulkheads will contain unallocated fibers. Spare fibers shall be terminated in accordance with the system or fiber optic cable topology drawings. Growth fibers shall not be terminated unless otherwise specified in the fiber optic cable topology drawings.

4.1.7.1.4 Unused fibers. The unused fibers shall not be terminated unless otherwise specified in the fiber optic cable topology drawings.

4.1.8 Cable testing. Cables shall undergo testing before, during, and after installation in accordance with Part 6 of this standard.

4.1.9 Cable and fiber marking. All cables shall be marked in accordance with the ship specification and system drawings and as specified herein. Cable identification tags external to the equipment shall be in accordance with MIL-STD-2189/305 and shall be located as specified in Part 4 of this standard. Cable tags shall be of a size suitable to accommodate the required marking but shall have a minimum width of 13 mm (1/2 inch). Tags and strips for marking cables shall be of soft aluminum tape having a natural finish in accordance with MIL-A-2877. Capital letters shall be used on cable tags; height of all letters shall be not less than 5 mm (3/16 inch), and letters and numbers shall be embossed to at least 0.4 mm (1/64 inch) above the surface.

4.1.9.1 Fiber identification markers. Heat shrink tubing marked with the fiber identification specified in the ship specification and system drawings shall be used to identify OFCC's or buffered fibers at their termination point within the interconnection box. The identification markers shall always be installed with the left hand marking group next to the termination point. The sleeve shall be positioned so that it can be easily read without disturbing other components within the equipment. Heat shrink tubing shall be white.

4.1.9.2 Heavy duty connector designation tag. Cables that terminate in a heavy duty connector shall have a tag placed on the cable next to the connector designating the jack to which the connector is to be attached.

4.1.10 Cable repair (see 3.16). Damage to the outermost fiber optic cable jacket shall be repaired according to procedures specified herein (see 5.2). Cable with damage extending beyond the cable outer jacket to the kevlar strength members or to the OFCC outer jacket shall be replaced.

4.2 Safety precautions. The following safety precautions apply:

a. Observe all written safety precautions given in the methods of this standard.

b. Observe all warning signs on equipment and materials.

c. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

d. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

e. Wash your hands after handling bare fibers.

5. DETAILED REQUIREMENTS

5.1 Cable end sealing. Unterminated cables that are not to be terminated within 48 hours shall have their ends sealed against moisture in accordance with Method 1A1 of this standard. OFCC's broken out within equipment (such as in an interconnection box) that are not to be terminated shall be grouped into bundles, with no more than eight OFCCs per bundle, and the bundle end sealed using Method 1A1 of this standard as a guide.

5.2 Cable repair. Damage to cable outer jackets (see 4.1.10) shall be repaired using cable jacket repair sleeves or tape, in accordance with Method 1B1 of this standard.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

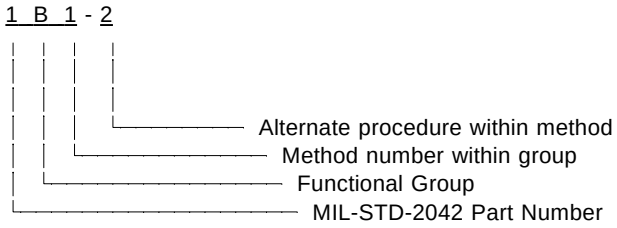
6.1 Intended use. The methods for cable end-sealing and cable repair depicted in this standard are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Standard method designation. To simplify the usage of this standard, an alpha-numeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Cable end sealing
Group B: Cable jacket repair

Then the designation system was completed as follows:



Thus, method 1B1-2 identifies the second alternate procedure within method 1 of group B in Part 1 (MIL-STD-2042-1) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Selection
Storage and handling
Marking
Penetrations
Connections
Testing
Repair
Component

Preparing activity:
NAVY - SH

(Project GDRQ-NXXX)

METHOD 1A1

CABLE END SEALING

1. SCOPE.

1.1 Scope. This method describes a procedure for fiber optic cable end sealing during temporary and long term storage to prevent water or other liquids from soaking into the cable and damaging the fibers.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 1A1-I shall be used to perform this procedure.

TABLE 1A1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
End cap (Raychem XFFR-07 series or equal)	1
Wipes	As required
Canned air	As required

3. PROCEDURE.

3.1 Safety Summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on the equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

NOTE: End caps shall meet the requirements of MIL-I-81765/1 and table 1A1-II. The tube interior shall be coated with a heat activated adhesive.

Step 1 - Clean the end of cable with a wipe dampened with alcohol and blow dry as necessary.

Step 2 - Select an end cap in accordance with table 1A1-II.

TABLE 1A1-II. End cap data and sizes for fiber optic cable.

Cable type	Cable O.D. mm (inches) nominal	End cap dimensions mm (inches)		
		Length (min)	Expanded I.D.(min)	Recovered I.D.(max)
4-Fiber	8.1 (0.32)	33.5 (1.32)	8.9 (0.35)	4.6 (0.18)

8-Fiber	11.1 (0.44)	69 (2.7)	20.6 (0.81)	9.4 (0.37)
36-Fiber	20.8 (0.82)	76 (3.0)	26.7 (1.05)	12.7 (0.50)

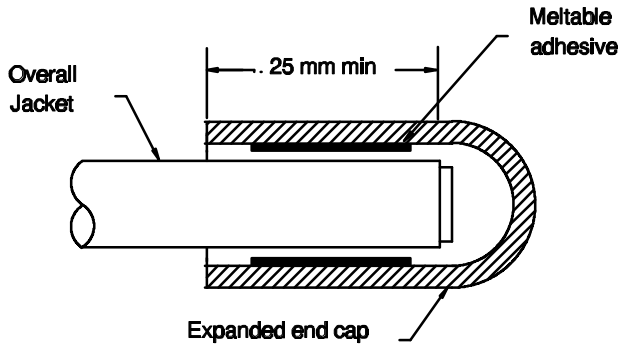


FIGURE 1A1-1. Installing expanded end cap on cable.

Step 3 - Slide the end cap over the end of the cable to be sealed. Position the end cap to ensure a 25 mm (1 inch) minimum overlap (see figure 1A1-1).

Step 4 - **CAUTION:** Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Hold the heat gun approximately 102 mm (4 inches) from the end cap and as heat is applied, move the heat gun back and forth over the end cap. Shrink the end cap from closed end to open end to avoid trapping air. (NOTE: Minimum recovery temperature is 121°C (250°F).

Step 5 - When the end cap has recovered enough to assume the configuration of the cable and excess adhesive appears at the end of the cap, discontinue heating (see figure 1A1-2). (NOTE: Additional heat will not make end cap shrink more tightly.)

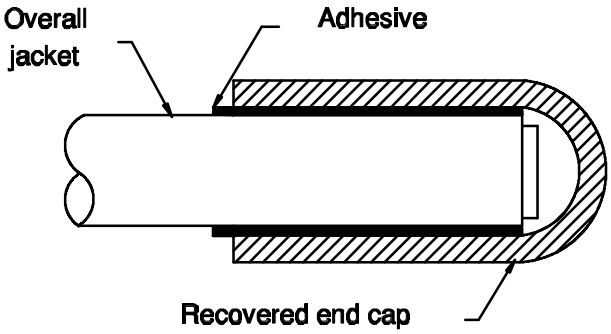


FIGURE 1A1-2. Completed end seal.

METHOD 1B1

CABLE JACKET REPAIR

1. SCOPE.

1.1 Scope. This method describes procedures for repairing the damaged outer jacket of a cable with kevlar strength members intact.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure I. Method 1B1-1. Wraparound sleeve with rail closure.

3.2.1 The equipment and materials in table 1B1-I shall be used to perform this procedure.

TABLE 1B1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Repair sleeve	1
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable jacket repair sleeve material shall meet the requirements of MIL-I-23053/15 and table 1B1-II. The material shall be coated with a heat-activated adhesive and fabricated into a wrap around sleeve with a rail closure system as shown on the figures below.

Step 1 - Select a repair sleeve in accordance with table 1B1-II.

Step 2 - Trim off the frayed, burned, or protruding jacket material with a knife using care not to damage the kevlar or OFCC jacket (see figure 1B1-1). Square up the jacketing where required.

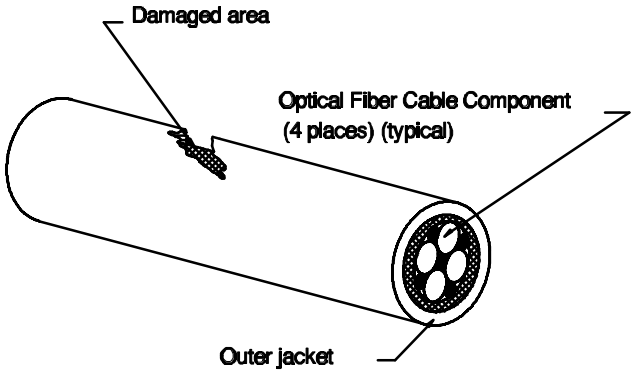


FIGURE 1B1-1. Damaged cable.

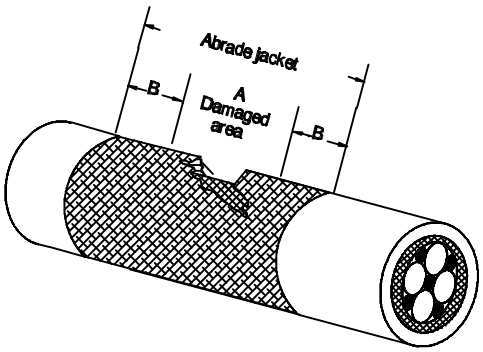


FIGURE 1B1-2. Cable preparation.

TABLE 1B1-II. Repair sleeve dimensions (wraparound).

Cable type	Cable O.D. nominal mm (inches)	B dimension mm (inches)	Repair sleeve dimensions mm (inches)			
			Length (minimum)	Rail to rail		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
4-fiber	8.1 (.32)	76 (3.0)	A + 2B	45.7 (1.8)	23.9 (.94)	2.0 (0.08)
8-fiber	11.1 (.44)	76 (3.0)	A + 2B	45.7 (1.8)	23.9 (.94)	2.0 (0.08)
36-fiber	20.8 (.82)	76 (3.0)	A + 2B	79.8 (3.14)	48.5 (1.91)	2.0 (0.08)

NOTE: Refer to figure 1B1-2 for a definition of A and B dimensions.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see table 1B1-II and figure 1B1-2).

Step 4 - Clean the abraded area with a wipe dampened with alcohol, and blow dry with air.

Step 5 - Fill any large depressions or voids with tape, as required, to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of the adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press it into the damaged area. Repeat the process until the damaged area is filled, then, holding the heat gun approximately 102 mm (4 inches) away, apply just enough heat to the tape to form and contour the tape to the cable (see figure 1B1-3).

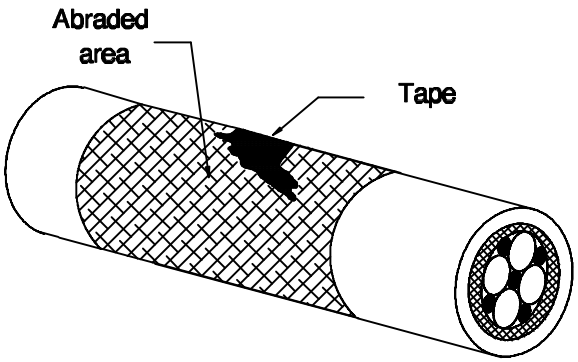


FIGURE 1B1-3. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-II).

Step 7 - **CAUTION:** Do not overheat the cable. The jacket should be just warm to the touch. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket.

Hold the heat gun approximately 102 mm (4 inches) away from the cable and apply heat to all parts of the cable jacket to which the repair sleeve is to be applied.

Step 8 - Assemble the repair sleeve as shown (see figure 1B1-4). Leave approximately 13 mm (0.5 inch) overhang of channel on both sides of sleeve (see figure 1B1-5).

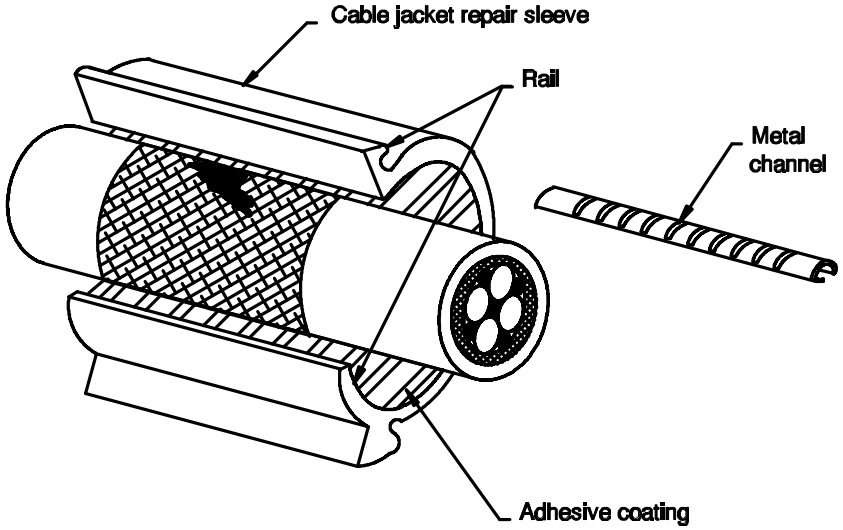


FIGURE 1B1-4. Installing sleeve.

Step 9 - **CAUTION:** Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

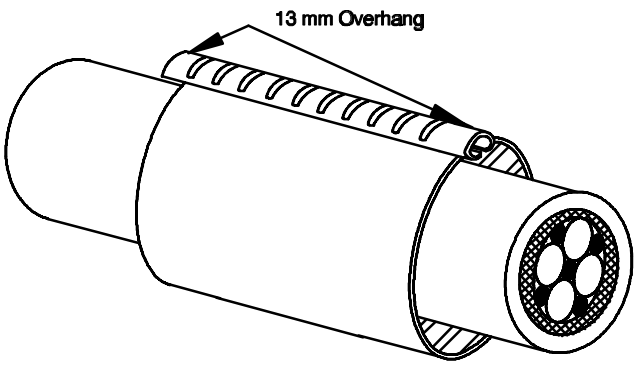


FIGURE 1B1-5. Assembled sleeve.

Center the sleeve over the damaged area and, holding the heat gun approximately 102 mm (4 inches) away, heat evenly from the center to the ends around the entire sleeve until the sleeve changes color indicating a full recovery (see figure 1B1-6). Melted sealant should be visible at the end of sleeve.

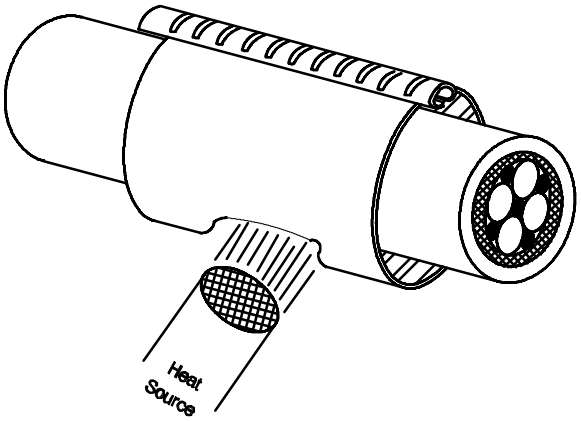


FIGURE 1B1-6. Shrinking sleeve.

Step 10 - When the sleeve has cooled, the rail and metal channel may be trimmed from the sleeve to provide greater flexibility to the cable (see figure 1B1-7).

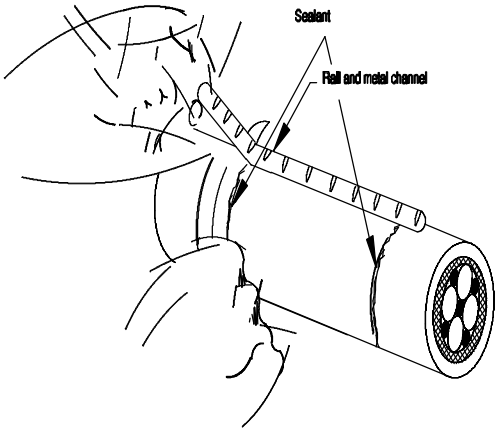


FIGURE 1B1-7. Trimming rails and metal channel.

3.3 Procedure II. Method 1B1-2 tube sleeve.

3.3.1 The equipment and materials in table 1B1-III shall be used to perform this procedure.

TABLE 1B1-III. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Repair sleeve (Raychem CRSM-1-1200 or equal)	1
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable repair sleeve material shall meet the requirements of MIL-I-23053/15 and table 1B1-IV. The material shall be coated with a heat activated adhesive and fabricated into a tube shape as shown on the figures below.

Step 1 - Select a repair sleeve in accordance with table 1B1-IV.

Step 2 - Trim off the frayed, burned, or protruding jacket material with a knife using care not to damage the kevlar or OFCC jacket (see figure 1B1-8). Square up the jacketing where required.

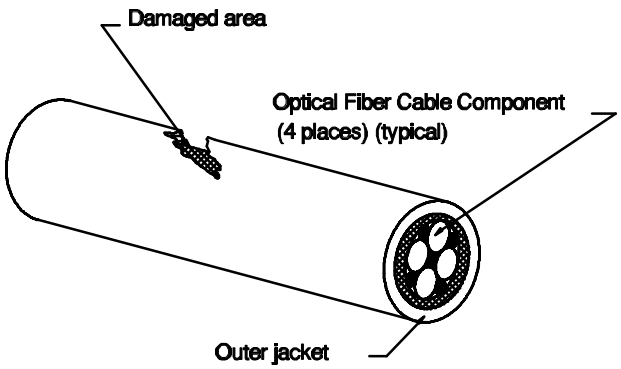


FIGURE 1B1-8. Damaged cable.

TABLE 1B1-IV. Repair sleeve dimensions (tube).

Cable type	Cable O.D. mm (inches) nominal	B Dimension mm (inches)	Repair sleeve dimensions mm (inches)			
			Length (minimum)	Inside diameter		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
4-Fiber	8.1 (.32)	201 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	3.0 (0.11)
8-Fiber	11.1 (.44)	101 (4.0)	A + 2B	19.1 (0.75)	5.6 (0.22)	3.0 (0.11)
36-Fiber	20.8 (.82)	101 (4.0)	A + 2B	28.0 (1.10)	9.6 (0.38)	3.0 (.12)

NOTE: Refer to figure 1B1-9 for a definition of A and B dimensions.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see table 1B1-IV and figure 1B1-9).

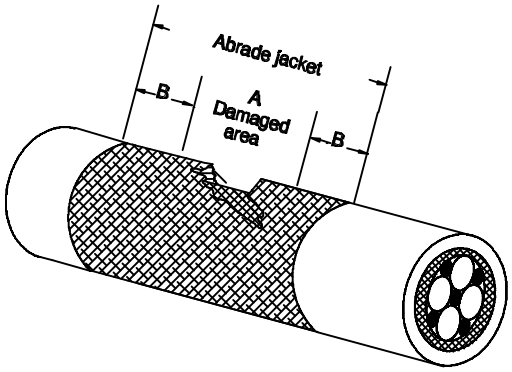


FIGURE 1B1-9. Cable preparation.

Step 4 - Clean the abraded area with alcohol and blow dry with air.

Step 5 - Fill any large depressions or voids with tape, as required, to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of the adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press it into the damaged area. Repeat the process until the damaged area is filled, then, holding the heat gun approximately 102 mm (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-10).

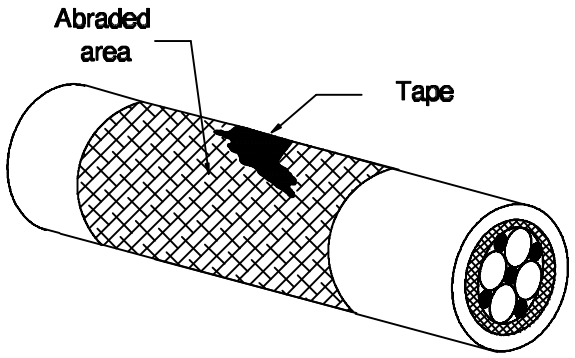


FIGURE 1B1-10. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-IV.)

Step 7 - **CAUTION:** Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the sleeve and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Center the repair sleeve over the damaged area. Hold the heat gun approximately 102 mm (4 inches) away and heat the center by applying heat evenly around the sleeve until it shrinks over cable (see figure 1B1-11). Working towards one end, shrink the sleeve to the cable until sealant is flowing at end of the sleeve. Repeat the procedure on the other half of the sleeve (see figure 1B1-12).

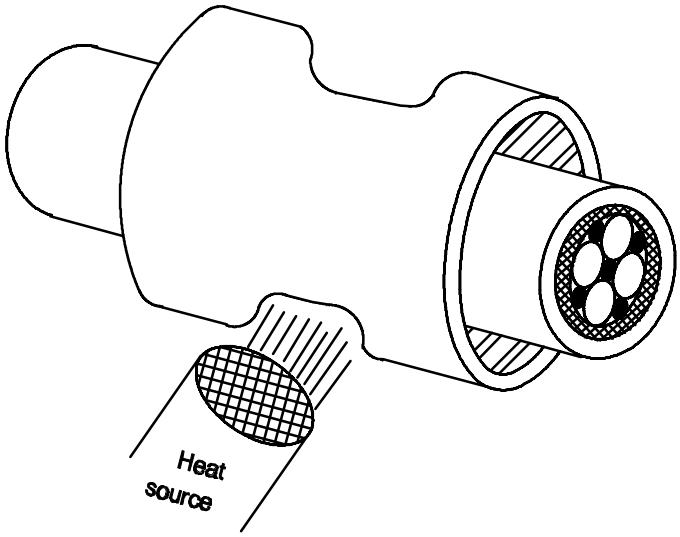


FIGURE 1B1-11. Shrinking the sleeve.

Step 8 - Remove heat and allow the sleeve to cool.

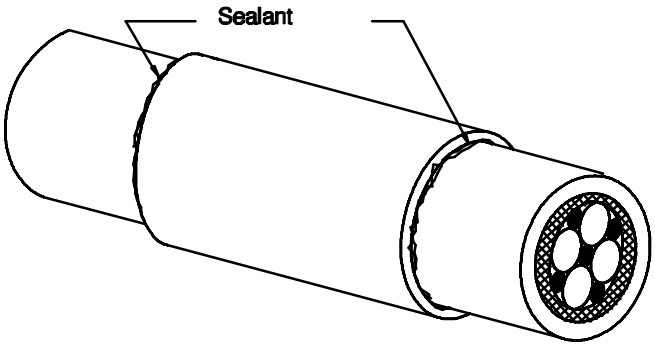


FIGURE 1B1-12. Completed repair.

3.4 Procedure III. Method 1B1-3 rubber tape.

3.4.1 The equipment and materials in table 1B1-V shall be used to perform this procedure.

TABLE 1B1-V. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Heat gun (Raychem 500B or equal)	1
Fiberglass tape (1 in.)	As required
Electrical coating (3M Scotch Kote or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

Step 1 - Trim off any frayed, burned, or protruding jacket material with a knife using care not to damage the kevlar or the OFCC jacket (see figure 1B1-13). Square up the jacketing where required.

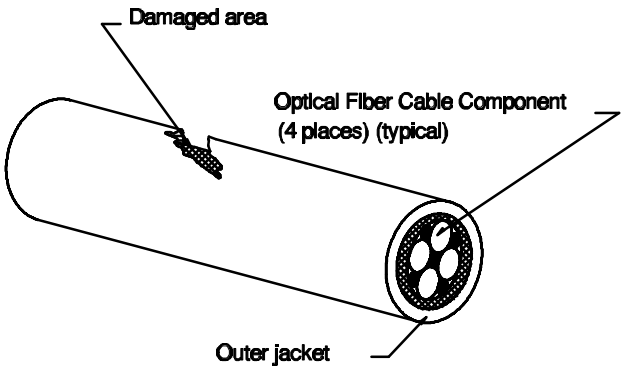


FIGURE 1B1-13. Damaged cable.

Step 2 - Abrade the jacket circumferentially approximately 76 mm (3 inches) on either side of the damaged area using emery cloth or a fine file (see figure 1B1-14).

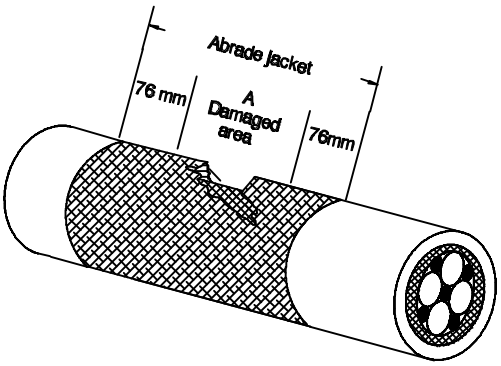


FIGURE 1B1-14. Cable preparation.

Step 3 - Clean the abraded area with alcohol and blow dry with air.

Step 4 - Fill any large depressions or voids with adhesive tape as required to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press them into the damaged area. Repeat process until the damaged area is filled, then, holding the heat gun approximately 102 mm (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-15).

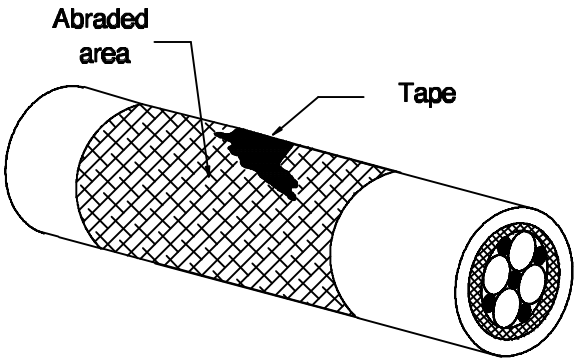


FIGURE 1B1-15. Tape contoured to the cable.

Step 5 - Cover the entire abraded area with one layer of half lapped adhesive and sealant tape, pulling the tape to approximately one-half its original thickness.

Step 6 - Cover the adhesive and sealant tape with one layer of half lapped fiberglass tape.

Step 7 - **CAUTION:** Do not over heat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the tape and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Holding the heat gun approximately 102 mm (4 inches) away from the cable, heat the entire area covered by the tape for approximately 3.5 minutes with the heat gun to blend the adhesive and sealant into the fiberglass tape.

Step 8 - Apply a coat of electrical coating to the entire area and let it set a minimum of 10 minutes.

3.5 Procedure IV. Method 1B1-4. Wraparound sleeve with adhesive closure.

3.5.1 The equipment and materials in table 1B1-VI shall be used to perform this procedure.

TABLE 1B1-VI. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Electricians knife	1
Emery cloth (or fine file)	As required
Adhesive and sealant tape (Raychem Thermofit S1030 or equal)	As required
Heat gun (Raychem 500B or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

NOTE: The cable repair sleeve material shall meet the requirements of MIL-I-23053/15 and table 1B1-VII. The material shall be coated with a heat activated adhesive and fabricated into a wrap with a self adhesive closure system as described below.

Step 1 - Select a repair sleeve in accordance with table 1B1-VII.

TABLE 1B1-VII. Repair sleeve dimensions (wraparound).

Cable type	Cable O.D. mm (inches) nominal	B Dimension mm (inches)	Repair sleeve dimensions mm (inches)			
			Length (minimum)	Inside diameter		Wall thickness after shrinking (+/- 10%)
				Expanded (minimum)	Recovered (maximum)	
36-Fiber	20.8 (.82)	76 (3.0)	A + 2B	31.8 (1.25)	12.7 (.50)	2.0 (0.08)

NOTE 1: Refer to figure 1B1-17 for a definition of A and B dimensions.
NOTE 2: Repair sleeves are not currently available for the 4-fiber and 8-fiber cable sizes.

Step 2 - Trim off any frayed, burned, or protruding jacket material with a knife using care not to damage the kevlar or the OFCC jacket (see figure 1B1-16). Square up the jacketing where required.

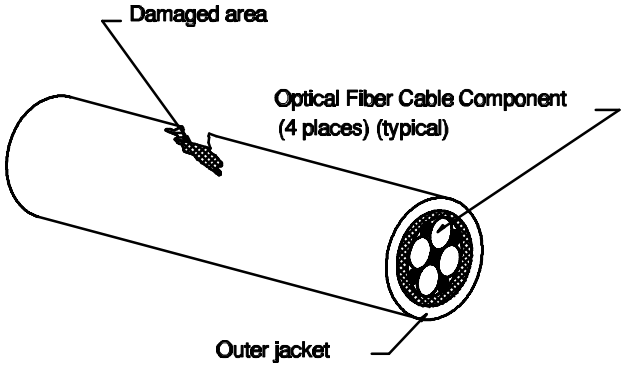


FIGURE 1B1-16. Damaged cable.

Step 3 - Abrade the jacket circumferentially to the dimension shown using emery cloth or a fine file (see figure 1B1-17).

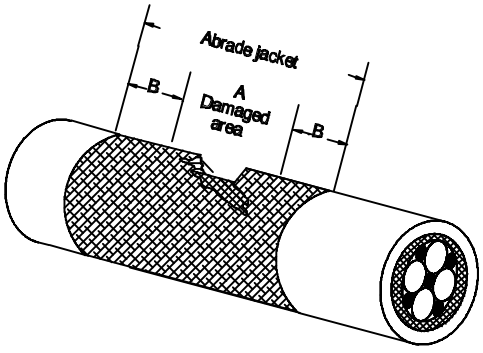


FIGURE 1B1-17. Cable preparation.

Step 4 - Clean the abraded area with alcohol and blow dry with air.

Step 5 - Fill any large depressions or voids with adhesive tape as required to restore the cable contour as follows:

WARNING: Application of too much heat will cause the adhesive to flow and may cause burns if it comes in contact with the skin.

Cut off short strips of adhesive tape and heat them slightly with the heat gun to soften them. Roll the tape with your fingers and press them into the damaged area. Repeat process until the damaged area is filled, then, holding the heat gun approximately 102 mm (4 inches) away, apply just enough heat to the tape to form and contour to the cable (see figure 1B1-18).

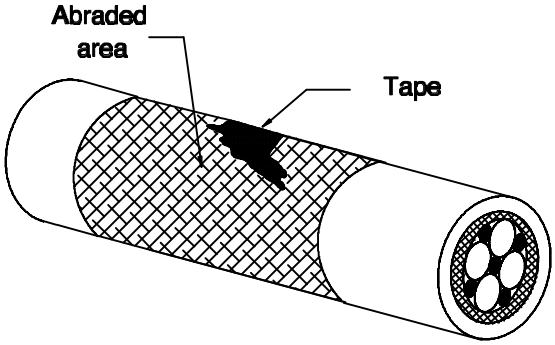


FIGURE 1B1-18. Tape contoured to cable.

Step 6 - Cut the cable jacket repair sleeve to the proper length (see table 1B1-VII.)

Step 7 - **CAUTION:** Do not overheat the cable. The jacket should be just warm to the touch. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket.

Hold the heat gun approximately 102 mm (4 inches) away from the cable and apply heat to all parts of the cable jacket to which the repair sleeve is to be applied.

Step 7 - Remove the protective release tape from both flaps of the sleeve to expose the surfaces of the contact adhesive.

Step 8 - Place the sleeve around the cable so that the sealant side of the sleeve is next to the cable, align the sleeve side edges, and press the contact surfaces together along the full length of the sleeve (see figure 1B1-19).

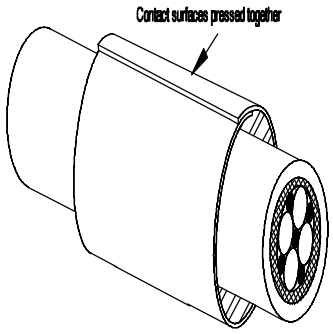


Figure 1B1-19. Assembled sleeve.

Step 9 - **CAUTION:** Do not over heat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the tape and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling.

Center the repair sleeve over the damaged area. Hold the heat gun approximately 102 mm (4 inches) away and heat the center by applying heat evenly around the sleeve until it shrinks over cable (see figure 1B1-20). Working towards one end, shrink the sleeve to the cable until sealant is flowing at end of the sleeve. Repeat the procedure on the other half of the sleeve (see figure 1B1-21).

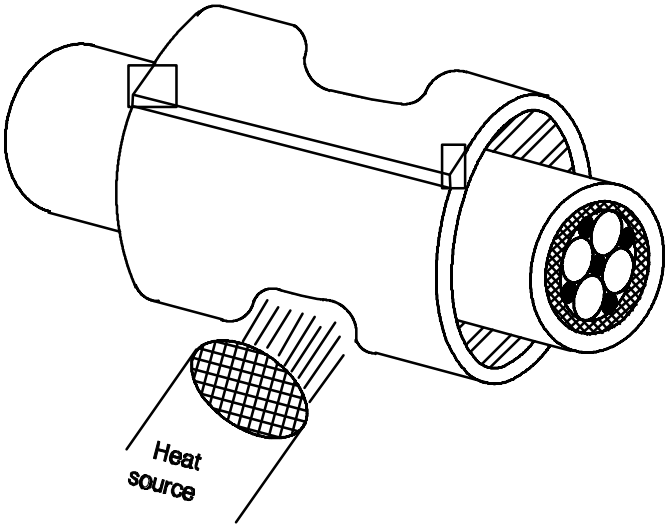


FIGURE 1B1-20 Shrinking sleeve.

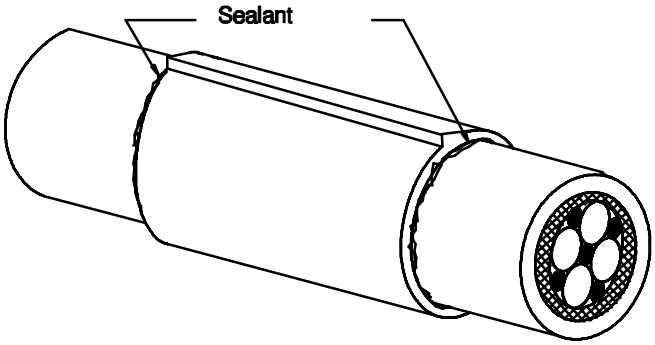


FIGURE 1B1-21. Completed repair.

Step 10 - Remove heat and allow the sleeve to cool.

NOTE: This draft, dated 15 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-2A(SH)

SUPERSEDING
MIL-STD-2042-2(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (EQUIPMENT)

(PART 2 OF 6 PARTS)

AMSC N/A

AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies (fiber optic cabling and associated components) on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installations to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

CONTENTS

CONTENTS

1. SCOPE

1.1 Scope. This standard provides detailed methods for the installation of fiber optic cable topology equipment (see 3.2), and fiber optic cable entry to fiber optic cable topology and other equipment.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. When there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-P-15024	- Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5	- Plates, Identification.
MIL-S-19622	- Stuffing Tubes, Nylon; and Packing Assemblies, General Specification for.
MIL-T-23053	- Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for.
MIL-T-23053/5	- Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked.
MIL-S-23190	- Straps, Clamps and Mountings, Plastic and Metal for Cable Harness Tying and Support.
MIL-S-24235	- Stuffing Tubes, Metal and Packing Assemblies for Electric Cables, General Specification for.
MIL-S-24623	- Splice, Fiber Optic Cable, General Specification for (Metric).
MIL-S-24623/4	- Splice, Fiber Optic, Housing, Fiber.
MIL-I-24728	- Interconnection Box, Fiber Optic, Metric, General Specification for.

STANDARDS

MILITARY

MIL-STD-278	- Welding and Casting Standard.
MIL-STD-461	- Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-889	- Dissimilar Metals.
MIL-STD-1310	- Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety.
DOD-STD-2003	- Electric Plant Installation Standard Methods for Surface Ships and Submarines.
DOD-STD-2003-1	- Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cable).
DOD-STD-2003-2	- Electric Plant Installation Standard Methods for Surface Ships and Submarines (Equipment).
MIL-STD-2042-1	- Fiber Optic Topology Installation Standard Methods for Naval Ships (Cables)(Part 1 of 6 Parts).

MIL-STD-2042-5 - Fiber Optic Topology Installation Standard Methods for Naval Ships (Connections and Interconnections)(Part 5 of 6 Parts).

MIL-STD-2042-6 - Fiber Optic Topology Installation Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWINGS

NAVSEA Drawing - 6872812 Tool Kit, MIL-S-24623, Fiber Optic, Navy Shipboard.

(Copies of documents should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, outlets, trunk and local cables and the connectors and splices used to interconnect the trunk and local cables.

3.3 Authorized approval. Authorized approval is written approval from the cognizant Government activity.

3.4 Installing activity. An installing activity is any military, commercial, or industrial organization involved with the installation of fiber optic cable topologies aboard Naval ships.

3.5 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.6 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.7 Minimum bend diameter. The minimum bend diameter of a fiber optic cable (and OFCC, see 3.15) is the radius at which the cable can be bent without degrading optical performance. The short term bend diameter applies during handling and installing; the long term bend diameter applies to the completed installation.

3.8 Normal channel. A normal channel is an allocated and used active link between system equipment that has a designated active backup link.

3.9 Alternate channel. An alternate channel is the allocated and used active backup link for a normal channel.

3.10 Non redundant channel (NRC). A non redundant channel is any allocated and used active link that has no system required backup link.

3.11 Unused fiber. An unused fiber is a fiber that is not designated for use for any system and not required as part of the cabling. Unused fibers occur within the fiber optic cable topology when the required systems fibers are less than the number of fibers available within a standard cable size.

3.12 Spare fiber. A fiber that is not allocated for use by any system, but is reserved for use as a maintenance spare in the case of damage to an allocated fiber within the cable. A system spare fiber is an allocated and not used fiber designated for a particular system.

3.13 Allocated and used fiber. An allocated and used fiber is a fiber that is designated and required for use for a particular system link, and is being used to transmit information. Allocated and used fibers include fibers used for normal channels, fiber for alternate channels, and fibers for non redundant channels.

3.14 Allocated and not used fiber. An allocated and not used fiber is a fiber that is designated for use for a particular system, but is not being used to transmit information. Allocated and not used fibers include fibers allocated as system spare fibers, system growth fibers, and system redundant fibers.

3.15 Optical fiber cable component (OFCC). An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket.

3.16 End user equipment. End user equipment refers to any cabinet, case, panel, or device, that contains components that are either the origin or destination of an optical signal.

3.17 Outlet. An outlet is a small termination box used to break out a local cable from and interconnection box to one or more equipments in a compartment or area.

3.18 Multiple cable penetrator (MCP). A MCP provides a means for making watertight, airtight, and firetight penetrations through decks, bulkheads, and into equipment.

4. GENERAL REQUIREMENTS

4.1 Fiber optic equipment installation. The methods specified herein are for installing the fiber optic cable topology equipment, which consists of interconnection boxes in accordance with MIL-I-24728. They may be extended to other fiber optic equipment only after obtaining authorized approval (see 3.3).

4.1.1 Interconnection box selection. The interconnection boxes selected shall be those identified in the ship specifications and drawings. Substitute boxes shall not be used without authorized approval (see 3.3). In those instances where the installing activity (see 3.4) is responsible for interconnection box selection, the box type shall be selected from MIL-I-24728. The box shall be sized to provide sufficient capacity to accept the total number of fibers entering the box (including growth fibers) as specified by the ship specification and system drawings. Unless otherwise specified in the ship specification or the system drawings, for boxes with both patch panels and splice trays, unused spaces can be any combination of patch panel or splice tray positions.

4.1.2 Location. Boxes shall be located in accordance with the system drawings. In those instances where the installing activity is responsible for selecting box location, the following requirements apply:

a. In instances where a box interfaces directly with only one end user equipment, the box shall be located as close as possible to that equipment without interfering with any other systems or violating any other requirements specified herein. If a box interfaces directly with two or more end user equipments, the box shall be so located as to keep the majority of local cable (see 3.5) runs as short as possible. For end user equipment with local cables that are required to be survivably separated, the boxes that connect these local cables to trunk cables shall be located in different compartments, except for the case where the interconnection box and the equipment are in the same compartment. In this situation, both cables may be run from the equipment to the same box.

b. Boxes shall be located in spaces protected from the weather whenever possible. Boxes shall not be installed in voids or inaccessible spaces. If mounting the box within gun or missile blast areas cannot be avoided, it shall be located clear of maximum deflection or whip of bulkheads and deck plating.

c. Box location shall provide ready access and entry for maintenance. No part of the box shall be at a height greater than 7 feet above the deck, with the preferred maximum height being 5 feet. There shall be a minimum of 2 feet of clearance in front of the box.

4.1.3 Interconnection box mounting. Interconnection boxes shall be mounted in accordance with methods specified in 5.1.

4.1.3.1 Bonding, grounding, and shielding. Boxes that contain active fiber optic components, such as switches, shall be bonded, grounded, and shielded in accordance with MIL-STD-1310. Bonding, grounding, and shielding inside the box shall be in accordance with MIL-STD-1310 and MIL-STD-461.

4.1.3.2 Holes drilled in beams. Holes drilled in structural members for passing cables or securing equipment shall be on the neutral axis of the beam or between the neutral axis and the point of attachment. Reinforcement of holes, where required, shall be in accordance with the applicable ship specification.

4.1.3.3 Welding. Unless otherwise noted, welding of studs, step hangers, tapped pads, mounting pads, and extension hangers shall be in accordance with MIL-STD-278. Any required tapping shall be done before welding.

4.1.3.4 Fasteners. Material for the bolts, nuts, machine screws and washers used to fasten boxes to decks and bulkheads shall be as specified in the ship specification and drawings, and in the methods described herein. Locking devices in accordance with ship specifications shall be used for bolts that secure the boxes. Through-bolts and self-locking nuts shall be used to mount boxes located:

a. In gun mounts.

b. In missile launch areas.

c. In submarine battery compartments above the level of the lowest cell tops.

4.1.3.5 Dissimilar metals. Where design requirements preclude the isolation of incompatible metal combinations, as identified in MIL-STD-889, from one another, the area in contact shall, as a minimum, be coated, treated, or otherwise insulated against corrosion in accordance with Appendix A of MIL-STD-889.

4.2 Cable entrance to equipment. Fiber optic cables shall enter equipment in accordance with the methods described herein and as follows:

a. Cables shall enter splashproof, spraytight, watertight, submersible, and explosionproof equipment through multiple cable penetrators (MCP's) integral to the equipment or through stuffing tubes. When stuffing tubes are used, entrance shall be made through the bottom or sides of the equipment where possible. Stuffing tubes used to enter splashproof, spraytight, or watertight equipment shall be nylon in accordance with MIL-S-19622. Stuffing tubes used to enter submersible (50 foot) and explosionproof equipment shall be metal in accordance with MIL-S-24235.

b. Cables shall enter molded plastic equipment through nylon stuffing tubes.

c. The entrance of cables via connector plugs and receptacles shall be as specified on the applicable ship or system drawings.

d. The entrance and grounding of electrical cables using MCP's integral to the equipment shall be as specified on the applicable ship or system drawings.

4.2.1 Cable slack. Cables shall be secured to ship structure as close as possible to the equipment without violating cable long term bend diameter (see 3.7) requirements of not less than sixteen times the cable outside diameter (O.D.). Cables entering hard-mounted equipment shall have sufficient slack between the equipment and the last point of cable support, to prevent damage to the cable caused by vibration. Cables connected to equipment provided with resilient or shock mounts shall have a minimum length of 457 mm (18 inches) with not less than 76 mm (3 inches) of slack between the equipment and the last point of support of the cable to provide for flexibility and movement of the equipment under shock, vibration, and in-service loading. Cables terminated in a heavy duty (multiple terminus) connector shall have an additional minimum of 254 mm (10 inches) of slack in the cableway from which the cable exits to provide for two reconnections. For cables that enter equipment by way of stuffing tubes or MCP's, there shall be enough slack inside the equipment for a minimum of two reconnections. Where connectors are used for cable entrance to equipment, the cables shall be installed such that the connectors may be easily removed.

4.2.2 Cable forming and shaping. Optical Fiber Cable Components (OFCC's) and buffered fibers within interconnection boxes shall be routed around the inside edges of the box such that they do not block or otherwise obstruct access to any connections within the box. The group or bundle of OFCCs shall be protected from possible damage on sharp edges by using ties, clamps or tubing. Care shall be taken when attaching the group or bundle as shown in the methods herein to prevent kinking or cutting the OFCC jackets and to ensure that bends do not violate the OFCC minimum short term bend diameter of eight times the OFCC O.D. and the minimum long term bend diameter of sixteen times the OFCC O.D.

4.2.3 Splice assembly and alignment. The mating and alignment of splice ferrules shall be accomplished after they enter the interconnection box as specified herein. The fiber optic splice ferrules shall be installed on the buffered fibers in accordance with Method 5C1 in Part 5 of this standard.

4.2.4 Interconnection organization. Fiber optic splices shall be installed in the splice tray mounted in the interconnection box. The splice tray shall be in accordance with MIL-S-24623 and MIL-S-24623/4. Fiber optic connectors and adapters shall be mounted on the optical patch panels mounted in the interconnection box. The position of each connector or splice shall be in accordance with system drawings. Unterminated fibers shall be tied off in the bundle. The reservation of unused connection or splice spaces for unterminated fibers shall be as specified in the ship specification. If the installing activity is responsible for the internal configuration of the interconnection box, the configuration shall be in accordance with 4.2.4.1 and 4.2.4.2.

4.2.4.1 Connector organization. The individual patch panels shall be filled starting with the row closest to the inside of the box and working outward (see figure 2-1). Allocated fibers [normal, alternate, and NRC fibers (see 3.8, 3.9, and 3.10) and system growth and spare fibers] shall be located nearest the inside of the box. Spare fibers (see 3.12) shall be located in close proximity to their respective allocated fibers. Unused adapters shall be located closest to the outside of the box.

4.2.4.2 Splice organization. The individual splice tray positions shall be filled starting with the tray position closest to the center of the box and working outward (see figure 2-2). Allocated fibers shall be located nearest the center of the box. Spare fibers shall be located in close proximity to their respective allocated fibers. Unused splice tray positions shall be located closest to the outside of the box. Each splice tray shall be filled starting closest to the rear of the box and working towards the front. Figure 2-3 shows typical splice tray configurations.

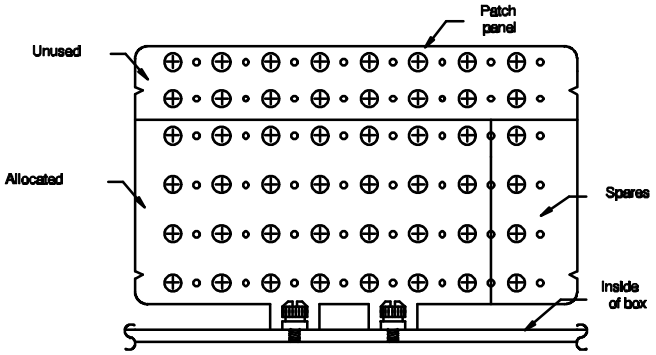


FIGURE 2-1. Configuration of patch panel - (typical).

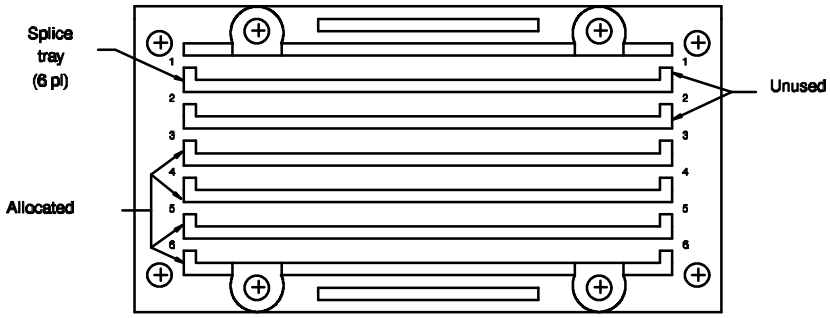


FIGURE 2-2. Configuration of splice module -(typical).

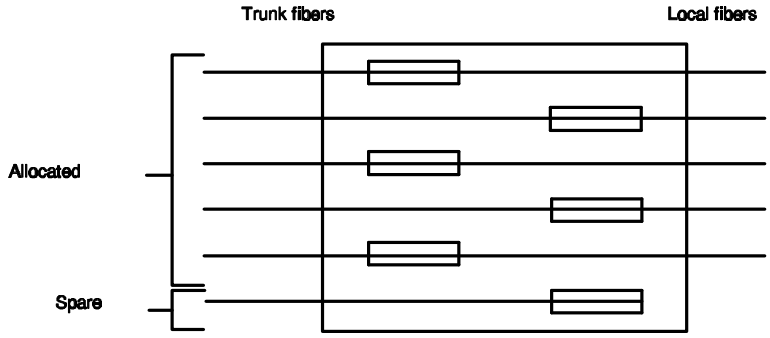


FIGURE 2-3. Configurations of splice tray - (typical).

4.2.5 Nameplates and marking. Nameplates shall be provided for all equipment and shall be in accordance with MIL-P-15024 and MIL-P-15024/5. Marking shall be as specified in the ship specification, applicable drawings, and the requirements herein. Interconnection box identification and location plates shall be located on the outside of the cover. Each connector or adapter position on the optical patch panels shall be marked. Splice trays shall be marked to identify each splice position, or a chart shall be attached in the box interior detailing the splice position numbers. A configuration

chart showing all the connections within the box shall be permanently attached to the inside of the box lid. The input and output cable and fiber numbers and the connector or splice position number shall be shown for each connection. Cable marking at an equipment end shall be in accordance with Part 1 of this standard.

4.3 Safety precautions. The following safety precautions apply:

a. Observe all written safety precautions given in the methods of this standard.

b. Observe all warning signs on equipment and materials.

c. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

d. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

e. Wash hands after handling bare fibers.

5. DETAILED REQUIREMENTS

5.1 Fiber optic interconnection equipment installation. The methods covered here are applicable to the fiber optic interconnection boxes. They may be extended to other fiber optic interconnection equipment only after contacting the contracting activity. The mounting of these boxes on ship structure is the same as the standard mounting methods of electrical enclosures given in DOD-STD-2003-2. These methods will not be repeated in this standard; however, they are identified and listed here to aid the user in rapidly locating the applicable method in DOD-STD-2003-2 to be used for installing the fiber optic interconnection box.

5.1.1 Non-watertight decks and bulkheads. The following methods shall be used to install the interconnection box on non-watertight decks and bulkheads:

a. Steel decks and bulkheads: DOD-STD-2003-2, Figure 2A1 or 2A4.

b. Aluminum decks and bulkheads: DOD-STD-2003-2, Figure 2A6 or 2A8.

5.1.2 Watertight decks and bulkheads. The following methods shall be used to install the interconnection box on watertight decks and bulkheads:

a. Steel decks and bulkheads: DOD-STD-2003-2, Figure 2A1 or 2A2.

b. Aluminum decks and bulkheads: DOD-STD-2003-2, Figure 2A6 or 2A7.

5.1.3 Stanchions. The following methods shall be used to install the interconnection box on stanchions:

a. Steel stanchion: DOD-STD-2003-2, Figure 2A5.

b. Aluminum stanchion: DOD-STD-2003-2, Figure 2A9.

5.1.4 Metal joiner bulkheads. The following method shall be used to install the interconnection box on metal joiner bulkheads:

DOD-STD-2003-2, Figure 2A11.

5.1.5 Expanded metal or wire mesh bulkhead. The following methods shall be used to install the interconnection box on expanded metal or wire mesh bulkheads:

DOD-STD-2003-2, Figure 2A12 or 2A13.

5.1.6 Refrigerated spaces. The following method shall be used to install the interconnection box in refrigerated spaces:

DOD-STD-2003-2, Figure 2A16.

5.1.7 GRP (glass reinforced plastic) bulkheads. The following methods shall be used to install the interconnection box on GRP bulkheads:

DOD-STD-2003-2, Figure 2A23 or 2A24 and Figure 2A25.

5.1.8 Locking devices for installations on submarines. Locking devices of the following method shall be used in the installation of the interconnection box on submarines:

DOD-STD-2003-2, Figure 2A21.

5.2 Cable entrance to equipment. Fiber optic cable entrance into equipment may employ the same devices (that is, stuffing tubes and cable clamps) used for electric cable entrance into equipment. When these devices are used and the procedures are the same for both cable types, the methods will not be repeated in this standard. However, the methods are identified and listed here to aid the user in rapidly locating the applicable method in DOD-STD-2003. Methods unique to fiber optic cable or that differ from those for electric cable shall be in accordance with this standard.

5.2.1 Nylon stuffing tubes. Cable entry into spraytight, splashproof, molded plastic and watertight equipment via nylon stuffing tubes shall be in accordance with Method 2A1 in this part of this standard.

5.2.2 Multiple cable penetrator (MCP). Cable entry into equipment via integral MCP's shall be in accordance with Method 2B1 in this part of this standard.

5.2.3 Cable clamps. Cable entry into equipment via cable clamps shall not be permitted, unless given approval from the contracting activity.

5.3 Interconnection organization. The organization of the splices, connectors and adapters and the shaping of the OFCC's and buffered fibers within the interconnection box shall be in accordance with Method 2C1 in this part of this standard.

5.4 Splice assembly and alignment. The interconnection of splice ferrules within the interconnection box shall be in accordance with Method 2D1 in this part of this standard.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

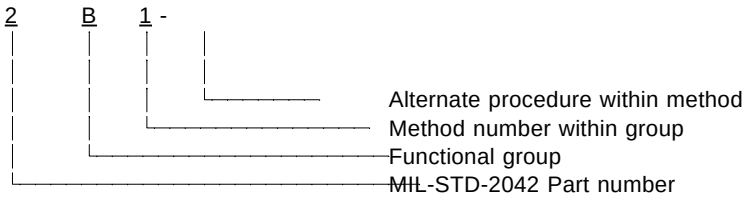
6.1 Intended use. The methods for equipment mounting and cable entrance to equipment depicted in this standard are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Standard method designation. To simplify the usage of this standard, an alpha-numeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Cable entrance to equipment via nylon stuffing tubes.
B: Cable entrance to equipment via MCP.
C: Cable and buffered fiber forming and shaping.
D: Splice assembly and alignment.

Then the designation system was completed as follows:



Thus, method 2B1 indicates there is no alternate procedure for method 1 of group B in Part 2 (MIL-STD-2042-2) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Interconnection box
Interconnection box selection
Entrance into equipment
Nameplates and marking
Component
Interconnection organization
Splice assembly and alignment

Preparing activity:
NAVY - SH

(Project GDRQ-NXXX)

METHOD 2A1

CABLE ENTRANCE TO EQUIPMENT VIA NYLON STUFFING TUBES

1. SCOPE.

1.1 Scope. This method describes a procedure for fiber optic cable entry to fiber optic cable topology and other equipment through nylon stuffing tubes.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 2A1-I shall be used to perform this procedure:

TABLE 2A1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Deburring tool (or equivalent)	1
Paint scraper	1
Emery cloth	As required
Cable jacket stripping tool (NAVSEA DWG 6872812-08 or equal)	1
Kevlar shears (NAVSEA DWG 6872812-16 or equal)	1
Open end wrench (sized to fit locknut)	1
Spanner wrench (sized to fit cap)	1
RTV silicone rubber (Silastic 731731 or equal)	As required
Primer (type to suit metal)	As required
Talc (soap stone)	As required
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air (or compressed air)	As required

3. PROCEDURE.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of bare fiber as they may be razor sharp. Wash your hands thoroughly after handling bare fibers.

c. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

3.2 Procedure.

NOTE: Packing assemblies and "O"-rings are not furnished with stuffing tubes. They must be ordered separately by the installing activity to suit installations.

Step 1 - Select the stuffing tube, packing and "O"-ring in accordance with tables 2A1-II and 2A1-III.

TABLE 2A1-II. Nylon stuffing tube sizes for fiber optic cable.

Cable type	Cable O.D. mm (inches) nominal	Tube size	Packing assembly part no. M19622/	Packing assembly opening mm (inches)
4-Fiber	8.1 (0.32)	2	17-0001	8.26 (0.325)
8-Fiber	11.1 (0.44)	3	18-0018	12.0 (0.472)
36-Fiber	20.8 (0.82)	5	20-0003	21.7 (0.853)

TABLE 2A1-III. Nylon stuffing tube data.

Stuffing tube sizes		Tube size 2	Tube size 3	Tube size 5
Straight tube	Tube part number M19622/	1-002	1-003	1-0006
	"O"-ring part number MS28775-	214	216	226
Angle tube	Tube part number M19622/	2-002	2-003	2-006
	"O"-ring part number MS28775-	212	216	226
NPT Tube	Tube part number M19622/	3-002	3-003	3-005
	NPT Tap mm (inches)	19 (0.75)	25 (1.0)	38 (1.5)
"Y" Tube	Tube part number M19622/	4-02	4-03	N/A
	"O"-ring part number MS28775-	214	216	N/A

Step 2 - **WARNING:** Wear safety glasses during deburring to avoid possible eye injury.

Inspect the hole in the enclosure and remove any burrs or irregularities using the deburring tool.

Step 3 - For steel enclosures where the roughness is greater than a 125 microinch finish (not required on aluminum enclosures), remove the paint using a paint scraper and clean the surface with emery paper approximately 0.5 inch (13 mm) wide around the hole on the exterior of the enclosure. Apply one coat of primer, and allow to set. Dust coat the surface with talc if the primer is not thoroughly dried at the time of the tube installation. Remove the cover and proceed to step 4, 5 or 7 below, as applicable.

Step 4 - With straight tubes, insert the stuffing tube body into the hole from the inside of the enclosure (see figure 2A1-1). If necessary, remove the interior fitting from enclosure. Proceed to step 6 below.

Step 5 - With "Y" and angle tubes, insert the stuffing tube body into the hole from the outside of enclosure (see figures 2A1-2 and 2A1-3). The excess length protruding into the enclosure may be removed.

Step 6 - Screw the locknut onto the body and tighten with a wrench against the "O"-ring sufficiently to obtain plastic to metal contact of the stuffing tube and the enclosure. In cases where this plastic to metal contact cannot be obtained, tighten the locknut until the threads start to skip. This is considered a satisfactory indication of tightness. (Note: Hold the stuffing tube body while tightening the locknut to prevent turning.) Proceed to step 8 below.

Step 7 - With NPT tubes, screw the tube into the enclosure pipe thread and tighten it sufficiently to obtain a seal at the threads (see figure 2A1-4).

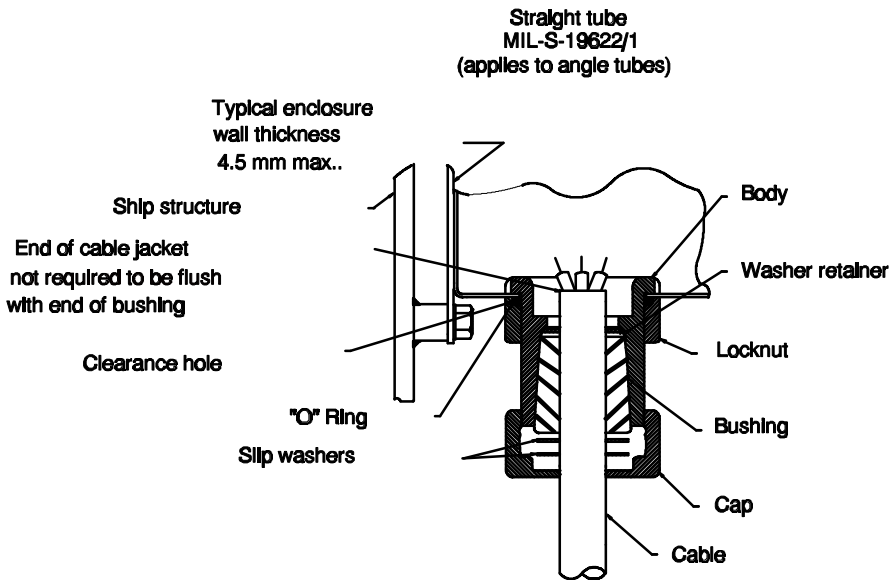


FIGURE 2A1-1. Straight tube.

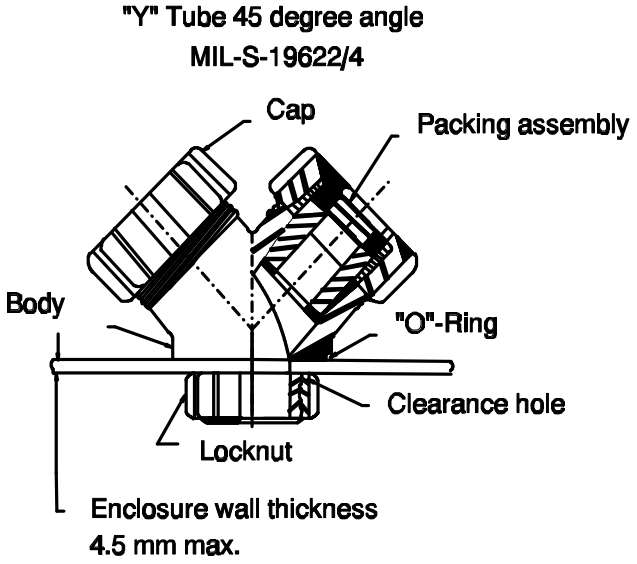


FIGURE 2A1-2. "Y" (45°) tube.

Step 8 - Measure the length of the cable jacket to be removed:

For unterminated cables, measure the distance required to route OFCCs from innermost portion of the stuffing tube completely around the interior of the interconnection box (or to the furthermost connection point in the end user equipment), add approximately 127 mm (5 inches) and mark cable outer jacket.

For terminated cable assemblies, measure the distance required to route OFCCs from innermost portion of the stuffing tube to the furthermost connection point in the equipment, add approximately 76 mm (3 inches) and mark cable outer jacket. In an interconnection box the distance measured shall be great enough that the OFCC can be routed one-half of the way around the box and then to the termination point.

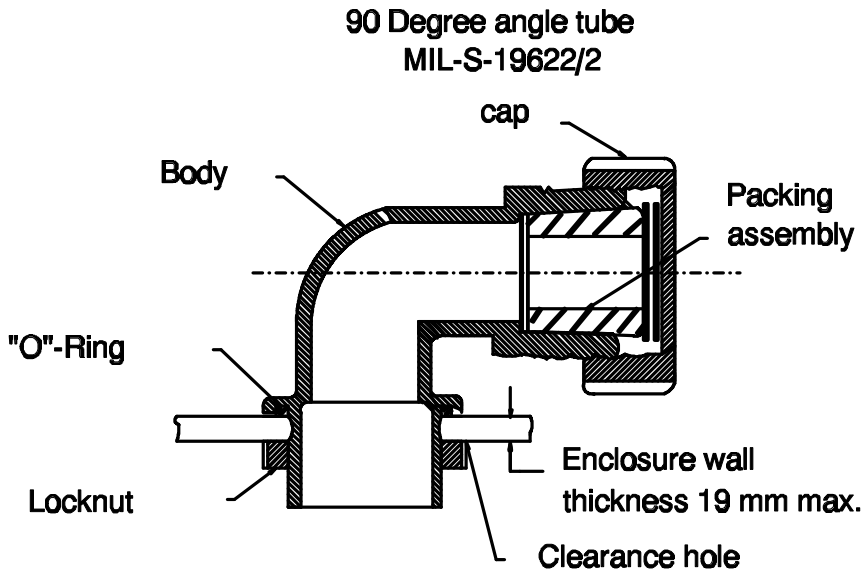


FIGURE 2A1-3. 90° angle tube.

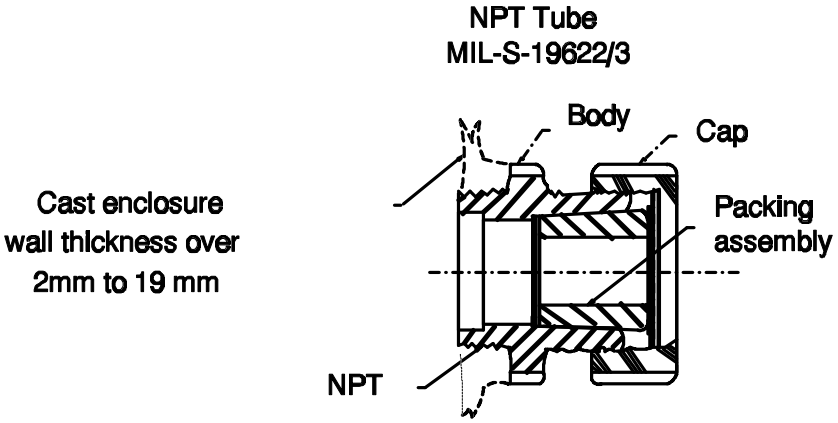


FIGURE 2A1-4. NPT tube.

Step 9 - Slide the stuffing tube parts onto cable in the order indicated:

a. Cap

b. Two slip washers

c. Rubber bushing

d. Bottom washer

Step 10 - Slide the parts up the cable beyond the mark and, if not already done, remove the outer jacket up to the mark using the cable stripper.

CAUTION: Do not cut or nick OFCC's.

Cut off the cable kevlar strength members and exposed central member, if present, using kevlar shears.

NOTE: If cable strength member capture is planned, leave approximately 102 mm (4 inches) of the kevlar strength members protruding from the cable jacket.

Step 11 - Remove the waterblocking material and clean the OFCC's using a wipe dampened with alcohol. Blow dry with air.

Step 12 - Insert the cable through the stuffing tube and into the enclosure so that the outer jacket protrudes 12 mm to 25 mm (0.5 in to 1 inch) inside the equipment. Slide the washers and bushing down the cable into the tube. (NOTE: When necessary to pass an airtight test, apply RTV silicone rubber to the bushing.)

Step 13 - Slide the cap down the cable, screw it onto the tube and tighten it sufficiently using the spanner wrench to compress the bushing to form a tight seal between the cable and the tube. (NOTE: Hold the tube body when tightening the cap to prevent breaking the watertight seal.) After the bushing has been compressed for approximately 24 hours, retighten it to ensure the seal is maintained.

Step 14 - If required, wind the exposed kevlar strength member under a screw lug attached beside the stuffing tube and tighten the screw lug.

Note: This step is only performed when additional strain relief is required beyond that provided by the stuffing tube assembly.

NOTE: Sealing plugs are for use in service to seal nylon stuffing tubes from which cables have been removed. When installing sealing plugs, the cable bushing shall be discarded but the nylon washers shall be retained and left in the stuffing tube.

Step 15 - Install connectors and splice ferrules on the OFCCs as specified on the system drawings using Method 5B1 in Part 5 of this standard for connectors and Method 5C1 in Part 5 of this standard for splice ferrules.

METHOD 2B1

CABLE ENTRANCE TO EQUIPMENT VIA MCP

1. SCOPE.

1.1 Scope. This method describes a procedure for fiber optic cable entry to fiber optic cable topology and other equipment through multiple cable penetrators (MCP) integral to the equipment being entered. Procedures for electrical cable entry and grounding to equipment through MCPs integral to the equipment shall be as specified on the applicable ship or system drawings.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 2B1-I shall be used to perform this procedure.

TABLE 2B1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Tallow (Hevi-Duty/Nelson AA0099 or equal)	As required
Open end wrench (sized to fit wedgepack nut)	1
Cable jacket stripping tool (NAVSEA DWG 6872812-08 or equal)	1
Kevlar shears (NAVSEA DWG 6872812-16 or equal)	1

3. PROCEDURE.

3.1 Safety Summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of bare fiber. Wash hands thoroughly after handling bare fibers.

c. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

3.2 Procedure.

Step 1 - Select MCP blocks in accordance with table 2B1-II.

Step 2 - Measure the length of the cable jacket to be removed:

For unterminated cables, measure the distance required to route OFCCs from innermost portion of the MCP completely around the interior of the interconnection box (or to the furthermost connection point in the end user equipment), add approximately 127 mm (5 inches) and mark the cable outer jacket.

For terminated cable assemblies, measure the distance required to route OFCCs from innermost portion of the MCP to the furthermost connection point in the equipment, add approximately 76 mm (3 inches) and mark the cable outer jacket. In an interconnection box the distance measured shall be great enough that the OFCC can be routed one-half of the way around the box and then to the termination point.

Step 3 - Remove the outer jacket up to the mark using the cable stripper.

CAUTION: Do not cut or nick OFCC's.

Cut off the cable kevlar strength members and exposed central member, if present, using kevlar shears.

Step 4 - Remove the waterblocking material and clean the OFCC's using a wipe dampened with alcohol. Blow dry with air.

TABLE 2B1-II. MCP data and insert block sizes for fiber optic cables.

Cable type	4-Fiber	8-Fiber	36-Fiber
Cable O.D. mm (inches) nominal	8.1 (0.32)	11.1 (0.44)	20.8 (0.82)
Primary insert block part number M24705/1-BN	1508	2011	3021
Alternate insert block part number M24705/1-BN	2008	N/A	N/A
Blanking insert block part number M24705/1-BN	15	20	30
Alternate blanking insert block part number M24705/1-BN	20	N/A	N/A

Step 5 - **CAUTION:** Do not exceed the cable minimum bend diameter of eight times cable O.D. for short term bends and sixteen times the cable O.D. for long term bends.

Feed the cables into the interconnection box or the other equipment through the cable penetration opening.

Step 6 - Liberally apply tallow to the outside portion of the insert blocks, the inner portion of the MCP frame and to the sides of the wedgepack. Make sure that tallow is placed in the corners of the MCP frame. (NOTE: The wedgepack may be removed and disassembled to apply the tallow.)

Step 7 - Reinstall the wedgepack (if removed) and install the insert blocks on the cables so that the outer jacket protrudes 13 mm (0.5 inch) to 25 mm (1 inch) inside the equipment. Install the cable insert blocks so that the gap between the insert block halves is parallel to the wedge pack. Install the insert blocks into the MCP frame so that the insert blocks are flush with the outside edge of the MCP frame. Fill all positions in the frame with insert blocks [either cable insert blocks or blanking (solid) insert blocks (see figure 2B1-1)]. (NOTE: Incoming cables may be installed on one end of the enclosure and outgoing cables on the opposite end for large enclosures. Where only one penetrator is used, incoming cables may be installed on one side of the wedgepack and outgoing cables on the opposite side.)

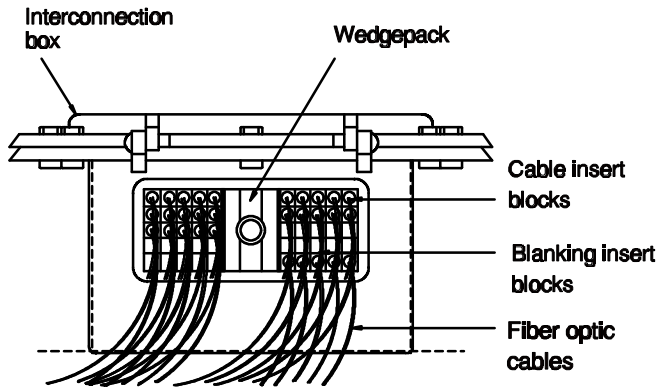


FIGURE 2B1-1. Interconnection box integral MCP-(typical).

Step 8 - Tighten the nut on the wedgepack to compress the insert blocks in the frame using a wrench. Tighten the wedgepack nut until the outside wedge pack metal plate is almost flush with the bottom of the MCP frame and the insert blocks. (NOTE: The wedge pack is fully tightened when the length of the pack is the same as the depth of the MCP frame.) Continue to tighten the wedgepack nut until a torque between 5.7 and 16.9 N-m (50 and 150 in-lbs) is reached. After the blocks have been compressed for approximately 24 hours, retighten the nut to ensure that the seal is maintained.

Step 9 - Install connectors and splice ferrules on the OFCCs as specified on the system drawings using Method 5B1 in Part 5 of this standard for connectors and Method 5C1 in Part 5 of this standard for splice ferrules.

METHOD 2C1

CABLE AND BUFFERED FIBER FORMING AND SHAPING

1. SCOPE.

1.1 Scope. This method describes a procedure for the forming and shaping of the optical fiber cable components (OFCC) and buffered fibers within the interconnection box and installation of connectors and splices in patch panels and splice trays, respectively.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 2C1-I shall be used to perform this procedure.

TABLE 2C1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Ruler	1
Self-clinching straps (MIL-S-23190 or commercial)	As required
Lacing (Nylon or equal)	As required
Synthetic tubing	As required
Heat shrink tubing (MIL-T-23053/5)	As required
Heat gun (Raychem 500B or equal)	1
Open end wrench	1
Alcohol bottle with alcohol/2-propanol	1
Wipes (NAVSEA DWG 6872812-18 or equal)	As required
Canned air (NAVSEA DWG 6872812-17 or equal)	As required

CAUTION: Throughout the fabrication process, cleanliness is critical to obtaining a high optical quality splice. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the connectors and splices.

3. PROCEDURE.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of bare fiber. Wash hands thoroughly after handling bare fibers.

c. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

3.2 Procedure.

3.2.1 Forming and shaping.

Step 1 - Verify that the procedures of Method 2A1 or Method 2B1 of this standard have been completed.

Step 2 - Open the enclosure cover and visually examine the OFCC's for cuts, nicks, kinks or twists before forming them into groups.

Step 3 - **CAUTION:** Do not exceed the bend diameter of eight times the OFCC O.D. for short term bends and sixteen times the OFCC O.D. for long term bends.

Observe the connection configuration chart or other approved drawing and form the fibers into groups based on their final destination. Groups may then be formed into bundles and shaped using lacing or self-clinching straps in accordance with DOD-STD-2003-1, Figures 1B5 and 1B6 respectively. Lace or strap the groups loosely; do not tighten down the straps with the hand tool.

Step 4 - Route the fiber bundles around the box securing them to the box mounting brackets using the self-clinching straps. Observe the following during routing (see figure 2C1-1):

a. All OFCCs shall be routed one-half of the way around the box and then to the termination point.

a. When a direct route to a termination point would exceed the OFCC long term bend diameter of sixteen times the OFCC O.D., an indirect route shall be used.

b. Groups and bundles shall not cross the splice trays or patch panels or in any other way obstruct access to the individual connectors, splices or adapters. Groups and bundles may be routed between the splice tray or connector patch panel modules, if necessary.

c. Groups and bundles shall be protected from possible damage by sharp edges by the use of supporting brackets or by synthetic tubing at the point of the sharp edge.

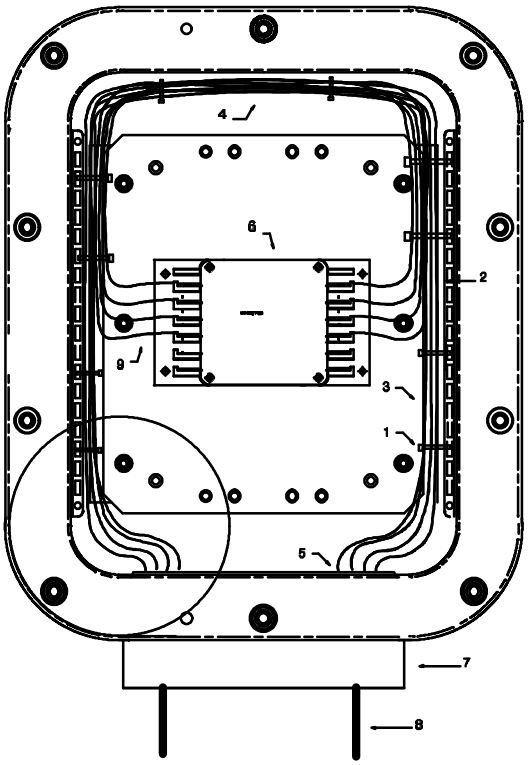


FIGURE 2C1-1. Forming and shaping - (typical).

Step 5 - Break out each separate OFCC from the group or bundle and, if not already done, slide the heat shrink tubing with the fiber identification over the connector or splice onto the OFCC cable jacket.

Note: The heat shrink tubing should normally be pushed up the OFCC before the OFCC is terminated. If the heat shrink is not put on before the connector or splice, heat shrink is available that can be installed after the connector or splice is installed.

Note: Do not install heat shrink tubing on 900 micron fibers. In those cases where 900 micron fiber is present going into a splice, the tubing should be installed in a region where there is an OFCC.

Step 6 - **CAUTION:** Do not overheat the OFCC. Prolonged exposure of the OFCC jacket to temperatures in excess of 160 degrees Celsius (°C) [320 degrees Fahrenheit (°F)] may damage the OFCC jacket. Discontinue heating of the tubing and allow the OFCC jacket to cool before reheating if the OFCC jacket shows any signs of bubbling.

Holding the heat gun approximately 102 mm (4 inches) away from the OFCC and tubing, shrink the tubing.

Step 7 - Form the unterminated OFCC bundles into a loop around the complete interior of the box being careful not to kink or otherwise damage the OFCCs and end seal the bundles in accordance with Part 1 of this Standard. Tie off the unterminated bundles such that they will not obstruct access to other components.

Note: Do not group or bundle the unterminated OFCCs with the terminated OFCCs. Unterminated OFCCs should be independently grouped, bundled and strapped to the box mounting brackets from the terminated OFCCs.

Step 8 - Proceed to 3.2.2 below to install connectors in patch panels. Proceed to 3.2.3 below to install splices in splice trays.

3.2.2 Connector installation in patch panel.

Step 1 - Unscrew the two screws holding the patch panel and pull the panel forward until it catches in the slide. (NOTE: The panel can be completely removed by pulling it through the catch.)

NOTE: Use a wipe dampened with alcohol to clean all connectors and blow them dry with air before making connections.

Step 2 - Insert one connector into the adapter mounted in the patch panel and lock it into place with the bayonet fitting. (This is accomplished by aligning the key on the connector barrel with the keyway on the adapter, inserting the connector in the adapter, engaging the bayonet coupling mechanism and rotating the connector clockwise until it stops.)

Step 3 - Insert the mating connector into the opposite side of adapter and lock it into place.

Step 4 - Repeat steps 2 and 3 above until all of the connectors are installed. Push the panel back into the box and tighten the screws.

Step 5 - Close and secure the cover.

3.2.3 Splice installation in splice tray.

Step 1 - Unscrew the four screws holding the splice tray holder cover, pull the splice tray forward and remove it from the holder. Remove the splice tray cover.

Step 2 - Place the ends of splice compression tool into the slots on the splice ferrule collars and squeeze the tool to compress the ferrule springs (see figure 2C1-2).

Step 3 - Carefully place the splice into the splice tray with the open slot in the splice alignment sleeve facing upward (see figure 2C1-3). Ensure the ferrule ends are completely inside the tray and that the buffered fibers are carefully routed in the tray slots.

Step 4 - Repeat steps 2 and 3 above until all of the splices are installed in the tray. Place the splice tray cover over the splice tray and reinstall the tray into the holder. Repeat the above procedures for each tray, as required.

Step 5 - Replace the tray holder cover and tighten the holder cover screws.

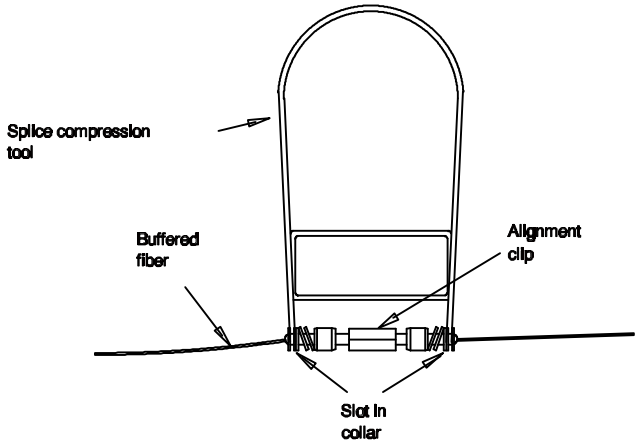


FIGURE 2C1-2. Compressing ferrule springs.

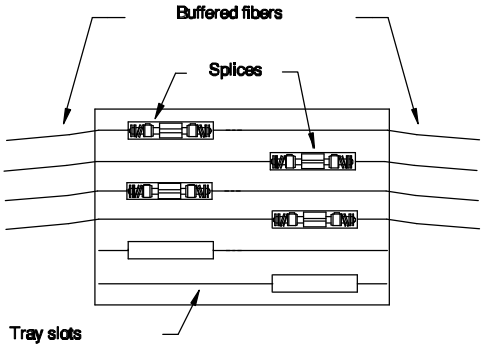


FIGURE 2C1-3. Splices installed in splice tray - (typical).

Step 6 - Close and secure the enclosure cover using a wrench.

METHOD 2D1

SPLICE ASSEMBLY AND ALIGNMENT

1. SCOPE.

1.1 Scope. This method describes a procedure for mating and aligning optical fibers terminated with MIL-S-24623/4 splice ferrules to form a continuous optical signal path.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 2D1-I shall be used to perform this procedure.

TABLE 2D1-I. Equipment and materials.

Description	Quantity
Safety glasses	1
Index matching gel (MIL-M-24794)	As required
Alignment clip tool (NAVSEA DWG 6872812-01 or equal)	1
Splice alignment tool (NAVSEA DWG 6872812-05 or equal)	1
Test jumpers (in accordance with table 6C1-III in Part 6 of this standard)	As required
Optical loss test set (NSN 7Z 6625 01 304 1739) or equal	1
Alcohol bottle with alcohol/2-propanol	1
Wipes (NAVSEA DWG 6872812-18 or equal)	As required

CAUTION: Throughout the fabrication process, cleanliness is critical to obtaining a high optical quality splice. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the splice.

3. PROCEDURE.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers.

b. Do not touch the ends of the fiber. Wash your hands thoroughly after handling bare fibers.

c. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or an LED.

3.2 Procedure.

3.2.1 Splice assembly.

Step 1 - Mix a small portion of the index matching gel on a clean surface according to the manufacturer's instructions provided (vacuuming is not required).

Note: The index matching gel provided may be a one part gel that does not require mixing.

Step 2 - **CAUTION:** Opening the sleeve too much may damage the sleeve.

Adjust the splice alignment clip tool so that it opens the splice alignment clip just enough to insert the splice ferrules. Insert the tool tip into the alignment sleeve slot. Open the sleeve (see figure 2D1-1).

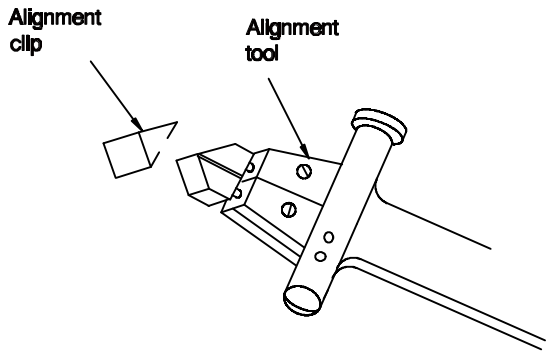


FIGURE 2D1-1. Opening alignment sleeve.

Step 3 - Dip one of the polished ferrule tips into the gel and slide the ferrule into the alignment clip until the tip is approximately centered in the clip (see figure 2D1-2).

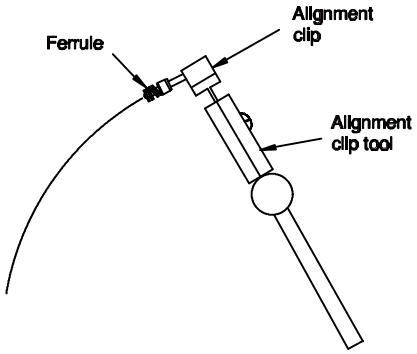


FIGURE 2D1-2. Inserting ferrule into alignment sleeve.

Step 4 - Dip the other ferrule tip into the index matching gel and slide the ferrule tip into the other side of the alignment clip (see figure 2D1-3). Ensure that the ferrule tips are centered in the alignment clip and the alignment tabs are facing the clip gap. Remove the alignment clip tool from the alignment clip. Verify that the ferrule tips are in contact by pushing the ferrules together.

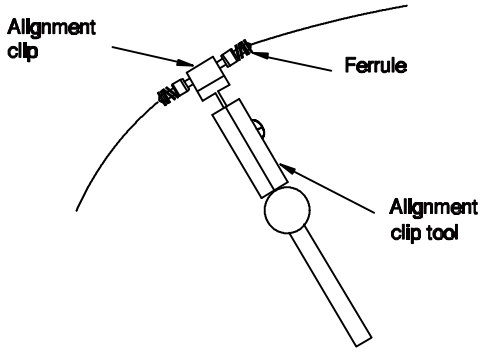


FIGURE 2D1-3. Inserting second ferrule into alignment sleeve.

3.2.2 Splice alignment.

NOTE: Passive alignment should be sufficient for most applications. Active alignment shall only be performed when required to meet link acceptance requirements.

Proceed to step 1 below for passive alignment or proceed to step 2 below for active alignment.

Step 1 - Passive alignment - verify the tab alignment by inserting the splice assembly into the splice alignment tool making sure the tabs fit into the tool slots (see figure 2D1-4). If necessary, rotate either ferrule slightly to align the tabs. Remove the splice from the tool.

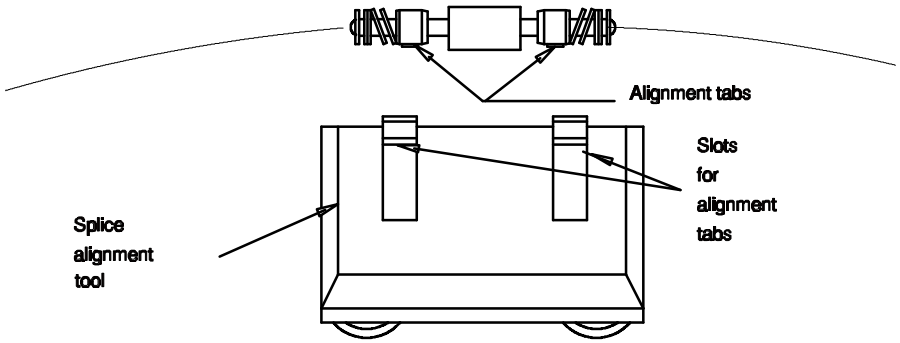


FIGURE 2D1-4. Aligning tabs.

Step 2 - Active alignment -

WARNING: Do not stare into the end of a fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

Using the appropriate test adapters or test jumper cables in accordance with table 6C1-III in Part 6 of this standard, connect the cable ends opposite the splice ferrules of cable under test to the light source and detector of two optical loss test sets and energize both (see figure 2D1-5).

Note: Both optical loss test sets should be allowed to warm up before starting the active alignment so that the readings are stable.

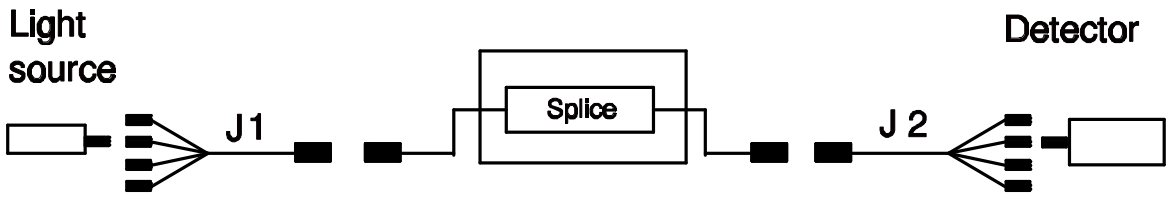


FIGURE 2D1-5. Active splice alignment cable hookup.

Step 3 - Rotate the ferrules relative to each other until the maximum power is recorded at the optical detector. De-energize the optical loss test sets.

NOTE: This draft, dated 15 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-3A(SH)

SUPERSEDING
MIL-STD-2042-3(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CABLE PENETRATIONS)

(PART 3 OF 6 PARTS)

AMSC N/A AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

CONTENTS

CONTENTS

1.SCOPE

1.1 Scope. This standard provides detailed methods of fiber optic cable penetrations through ship structure and equipment via stuffing tubes, swage tubes, multiple cable penetrators, chafing collars and nipples.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. When there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

GGG-W-646	- Wrench, Open End, Ratchet (TAC Pattern), for Tube Fittings, Electrical Cable Terminals and Stuffing Tube Gland Nuts.

MILITARY

MIL-I-3064	- Insulation, Electrical, Plastic-Sealer.
MIL-R-15624	- Rubber Gasket Material, 50 Durometer Hardness (Maximum).
MIL-P-16685	- Packing, Material and Packing Preformed (Stuffing Tube for Electrical Cables).
MIL-S-24235	- Stuffing Tubes, Metal and Packing Assemblies for Electric Cables, General Specification for.
MIL-S-24235/1	- Stuffing Tube, Metal, and Packing Assemblies for Electric Cables, Bulkhead, Pressureproof.
MIL-S-24235/9	- Stuffing Tubes, Metal and Packing Assemblies for Electric Cables, Brass and Steel, for Decks and Bulkheads with Pipe Protection.
MIL-S-24235/10	- Stuffing Tubes, Metal and Packing Assemblies for Electric Cables, Steel, for Decks and Bulkheads without Pipe Protection.
MIL-S-24235/17	- Stuffing Tube, Metal, and Packing Assemblies for Electric Cables, Swage Type, Steel and Aluminum, for Deck and Bulkheads with Pipe Protection.
MIL-S-24235/18	- Stuffing Tube, Metal, and Packing Assemblies for Electric Cables, Swage Type, Reduced Diameter, Steel and Aluminum, for Deck and Bulkheads with Pipe Protection.
MIL-P-24705	- Penetrators, Multiple Cable, for Electric Cables, General Specification for.

STANDARDS

MILITARY

DOD-STD-2003	- Electric Plant Installation Standard Methods for Surface Ships and Submarines.
DOD-STD-2003-3	- Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations).
MIL-STD-2042-2	- Fiber Optic Topology Installation Standard Methods for Naval Ships (Equipment).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DOCUMENTS

DDS 100-1 - Reinforcement of Openings in Structure of Surface Ships Other than in Protective Plating.

DDS 100-2 - Openings in Decks and Bulkheads for Stuffing Tubes and Pipe.

(Copies of documents should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Metal stuffing tube. A metal stuffing tube provides a means for making watertight single cable penetrations through shell plating, decks, and bulkheads, and into equipment.

3.3 Swage tube. A swage tube provides watertight cable penetrations through decks and is an alternative to a stuffing tube with a kickpipe.

3.4 Multiple cable penetrator (MCP). A MCP provides a means for making watertight, airtight, and firetight penetrations through decks, bulkheads, and into equipment.

3.5 Chafing collar. A chafing collar is a round or oval banding that protects two or more cables that penetrate structure from crimping and wear caused by rubbing against sharp edges.

3.6 Nipple. A nipple is a smaller version of the chafing collar, and is used to protect a single cable penetration.

3.7 Collective protection system (CPS). A CPS system is a system designed to inhibit the entry of chemical, biological, and radiological contaminants into collective protection zones on board Naval ships.

3.8 Kickpipe. A kickpipe is a pipe welded into the deck with a stuffing tube attached. Kickpipes provide protection for cables at deck penetrations and are used to clear an obstruction or preserve alignment.

4. GENERAL REQUIREMENTS

4.1 Cable penetrations. Fiber optic cable penetrations of ship structure shall be made by metal stuffing tubes (see 3.2), swage tubes (see 3.3), multiple cable penetrators (see 3.4), chafing collars (see 3.5), or nipples (see 3.6). Cable penetrations into equipment shall be made by nylon stuffing tubes or integral multiple cable penetrators in accordance with Part 2 of this standard. Penetrations of ship structure shall be in accordance with this Part of this standard.

4.1.1 Cable penetration of ship structure. Cable penetration of ship structure shall be in accordance with DDS 100-1, DDS 100-2, the methods described herein, and as follows:

a. Metal stuffing tubes or multiple cable penetrators (MCP's) shall be used for the penetration of the following structures, except that only metal stuffing tubes shall be used to penetrate bulkheads or decks that are exposed to the weather:

   (1) Collective protection system (CPS) (see 3.7) boundaries.

   (2) Watertight cable trunks.

   (3) Watertight decks.

   (4) Watertight bulkheads.

   (5) Bulkheads designed to withstand a waterhead.

   (6) That portion of a bulkhead specified to be watertight to a certain height.

   (7) That portion of a bulkhead below the height of the sill or the coaming of a compartment access.

   (8) Bulkheads surrounding compartments subject to flooding by sprinkling systems.

   (9) Garbage disposal rooms.

   (10) Battery shops.

   (11) Medical operating rooms.

   (12) Medical wards.

b. Metal stuffing tubes only shall be used to penetrate decks and bulkheads forming the boundaries of spaces containing volatile, combustible, or explosive material.

c. Unless otherwise specified, metal stuffing tubes, multiple cable penetrators or nipples and chafing collars packed with plastic sealer shall be used for the following penetrations. The method selected shall satisfy the tightness requirements of the structure.

   (1) Decks (non-watertight).

   (2) Structural bulkheads.

   (3) Airtight bulkheads.

   (4) Fumetight bulkheads.

   (5) Multiple cable (two or more) penetrations through non structural steel bulkheads (other than mesh or expanded metal), bents, web frames, transverse girders and longitudinal girders.

   Cable penetrations of vertical non tight structures within a compartment need not be sealed at intervals closer than 20 feet horizontally. However, if one penetration on the structure requires sealing, then all penetrations of that structure shall be sealed.

d. Metal stuffing tubes in accordance with MIL-S-24235/1 shall be used to penetrate pressureproof submarine bulkheads and surface ship sonar domes that are filled with water under normal operating conditions. One half of the tube may be used to penetrate surface ship sonar domes only.

e. The size of the stuffing tube groups shall be limited to permit tightening of gland nuts in the group using stuffing tube wrench set type II, class I, style A, form B in table IV of GGG-W-646. Penetration spacing shall be as specified in DDS 100-2.

4.1.2 Plastic sealer. Plastic sealer, type HF as specified in MIL-I-3064 shall be used to seal the space around the cables in collars or nipples used for passing cables through light tight and fume tight bulkheads.

4.1.3 Kickpipes. Kickpipes (see 3.8) shall be made of a material to suit the structure being penetrated and shall be compatible with the stuffing tube material. Pipe ends shall be chamfered and inside wall burrs shall be removed to prevent chafing of the cable jacket. Swage tubes in accordance with MIL-S-24235/17 or MIL-S-24235/18 may be used as an alternative to stuffing tubes in accordance with MIL-S-24235/9.

4.1.4 Multiple cable penetrators (MCP's). MCP's shall be in accordance with MIL-P-24705.

4.1.5 Metal stuffing tubes. Metal stuffing tubes shall be in accordance with MIL-S-24235/1, MIL-S-24235/2, MIL-S-24235/9 or MIL-S-24235/10.

4.1.5.1 Stuffing tube packing. Packing for stuffing tubes that penetrate submarine pressureproof and surface ship ballistic bulkheads, and sonar domes filled with water under normal operating conditions shall be in accordance with MIL-S-24235/1. For all other metal stuffing tubes, packing shall be in accordance with either the preformed (coil), class 2 or the bulk, class 1 of MIL-P-16685. When bulk packing is used, the first and last turns shall be part A (hard) and the intermediate turns shall be part B (soft). Reinforced neoprene packing in accordance with class 1 of MIL-R-15624 may be used as an alternate.

4.1.6 Chafing collars and nipples. Collar length shall be not less than 76 mm (3 inches) with a minimum radial distance between the cable and collar of 25 mm (1 inch). Nipple length shall be not less than 51 mm (2 inches), with a minimum radial distance between the cable and the nipple of 6 mm (0.25 inch).

4.2 Safety precautions. The following safety precautions apply:

a. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

b. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

c. Wash hands after handling bare fibers.

5. DETAILED REQUIREMENTS

5.1 Penetration of ship structure (submarines). Fiber optic cables shall penetrate the ship structure of submarines in accordance with Figures 3A1 and 3A10 through 3A23 of DOD-STD-2003-3, as modified (see 5.5). Stuffing tube sizes for fiber optic cables shall be selected in accordance with Method 3A1-1 of this standard.

5.2 Penetration of ship structure (surface ships) using steel or aluminum stuffing tubes. Fiber optic cables shall penetrate the ship structure of surface ships using steel or aluminum stuffing tubes in accordance with Figures 3B1 through 3B3, 3B10 through 3B24, 3B43 through 3B46, 3B48 and 3B49, 3C13 through 3C16 and 3C18 of DOD-STD-2003-3, as modified (see 5.5). Stuffing tube sizes for fiber optic cables shall be selected in accordance with Method 3A1-2 of this standard.

5.3 Penetration of ship structure using multiple cable penetrators (MCP's). Fiber optic cables shall penetrate the ship structure using MCP's in accordance with Figures 3B25, 3B27 through 3B35, and 3B54 through 3B66 of DOD-STD-2003-3, as modified (see 5.5). MCP insert block sizes for fiber optic cables shall be selected in accordance with Method 3B1 of this standard.

5.4 Penetration of ship structure using kickpipes. Fiber optic cables shall penetrate the ship structure using kickpipes in accordance with Figures 3D1 through 3D6 and 3D8 of DOD-STD-2003-3, as modified (see 5.5). Stuffing tube sizes for fiber optic cable shall be in accordance with Method 3A1-2 of this standard. Swage tubes may be used in place of kickpipes. Swage tube sizes for fiber optic cable shall be selected in accordance with Method 3A1-3 of this standard.

5.5 Retention of the watertight seal. The fiber optic cable may lose some of its resiliency after being compressed. To ensure the watertight seal is achieved and maintained, retighten cap (stuffing tube) or bolt (MCP) approximately 24 hours after initial compression.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

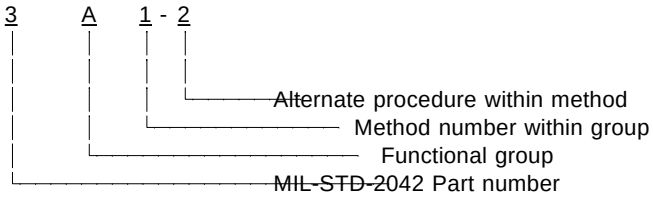
6.1 Intended use. The methods for cable penetrations depicted in this standard are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1).

6.3 Standard method designation. To simplify the usage of this standard, an alpha-numeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Cable penetrations via metal stuffing tubes
Group B: Cable penetrations via MCP

Then the designation system was completed as follows:



Thus, method 3A1-2 identifies the second alternate procedure for method 1 of group A in Part 3 (MIL-STD-2042-3) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Metal stuffing tubes
Swage tubes
Kickpipes
Chafing collar
Nipple
Multiple cable penetrator (MCP)
Collective protection system (CPS)

Preparing activity:
NAVY - SH
(Project GDRQ-NXXX)

METHOD 3A1

CABLE PENETRATIONS VIA METAL STUFFING TUBES

1.1 Scope. These methods identify stuffing tube sizes used to pass fiber optic cables through decks and bulkheads. The methods for installation of the stuffing tubes is the same as those specified for electrical cables in DOD-STD-2003. These installation methods are not repeated in this standard but they are identified in paragraph 5 in this part of this standard.

2. REQUIRED EQUIPMENT AND MATERIALS. (Not applicable.)

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed during the passing of fiber optic cables through the installed stuffing tubes:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of fibers as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe the warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure I. Method 3A1-1-Metal stuffing tubes for submarines.

Step 1 - Select a steel stuffing tube from those shown in tables 3A1-I and 3A1-II.

TABLE 3A1-I. Steel stuffing tube sizes for fiber optic cable (Submarines).

Cable type	Cable O.D. mm (inches) (nominal)	Tube size	Packing assembly	
			Part no. M24235/2	Symbol no.
4-Fiber	8.1 (0.32)	1	-*002	2405.2
8-Fiber	11.1 (0.44)	1	-*003	2405.3
36-fiber	20.8 (0.82)	3	-*013	2407.1

NOTE: The asterisk "*" represents item material. The material shall be Neoprene (N) or Silicone (S).

TABLE 3A1-II. Steel stuffing tube data (Submarines).

Grade steel		HY-80		HT	
		Tube size 1	Tube size 3	Tube size 1	Tube size 3
Stuffing tube assembly	Part number M24235/1	-001	-003	-101	-103
Part numbers of components	Tube body (1 required) M24235/1	-010	-012	-110	-112
	Gland nut (2 required) M24235/1	-019	-021	-019	-021
	Lock washer (2 required) M24235/1	-028	-030	-028	-030
Symbol number		2405 HY-80	2407 HY-80	2405-HT	2407-HT

3.3 Procedure II. Method 3A1-2- Metal stuffing tubes for surface ships.

Step 1 - Select a steel or aluminum stuffing tube from those shown in tables 3A1-III and 3A1-IV.

TABLE 3A1-III. Aluminum and steel stuffing tube sizes for fiber optic cable (Surface ships).

Cable type	Cable O.D. mm (inches) (nominal)	Tube size MIL-S-24235 /9 and /10	Packing assembly MIL-P-16685
4-Fiber	8.1 (0.32)	A	Class 1 and 2
8-Fiber	11.1 (0.44)	B	Class 1 and 2
36-fiber	20.8 (0.82)	F	Class 1 and 2

TABLE 3A1-IV. Steel stuffing tube data for decks and bulkheads with and without pipe protection.

Tube type		Without pipe protection			With pipe protection		
Tube size		A	B	F	A	B	F
Stuffing tube assembly	Part number M24235/	10-01	10-02	10-06	09-121	09-122	09-126
Part numbers of components	Tube body (1 required) M24235/	10-31	10-32	10-36	09-151	09-152	09-156
	Gland nut (1 required) M24235/	09-061	09-062	09-066	09-061	09-062	09-066
	Gland ring (1 required) M24235/	09-181	09-182	09-186	09-181	09-182	09-186
Symbol number		1600	1601	1605	1570	1571	1575

3.4 Procedure III. Swage type stuffing tubes.

Step 1 - Select swage type aluminum or steel stuffing tubes from those shown in tables 3A1-V, 3A1-VI, 3A1-VII or 3A1-VIII respectively.

TABLE 3A1-V. Swage type aluminum stuffing tube data for decks and bulkheads.

Tube type		Bulkheads			Decks		
Tube size		A	B	F	A	B	F
Stuffing tube assembly	Part number M24235/17	-031	-032	-036	-091	-092	-096
Part numbers of components	Tube body (1 required) M24235/17	-151	-152	-156	-211	-212	-216
	Gland nut (1 required) M24235/17	-241	-242	-246	-241	-242	-246
	Gland ring (1 required) M24235/17	-271	-272	-276	-271	-272	-276
Symbol number		1731	1732	1736	1791	1792	1796

TABLE 3A1-VI. Swage type steel stuffing tube data for decks and bulkheads.

Tube type		Bulkheads			Decks		
Tube size		A	B	F	A	B	F
Stuffing tube assembly	Part number M24235/17	-001	-002	-006	-061	-062	-066
Part numbers of components	Tube body (1 required) M24235/17	-121	-122	-126	-181	-182	-186
	Gland nut (1 required) M24235/09	-061	-062	-066	-061	-062	-066
	Gland ring (1 required) M24235/09	-181	-182	-186	-181	-182	-186
Symbol number		1701	1702	1706	1761	1762	1766

TABLE 3A1-VII. Reduced diameter swage type aluminum stuffing tube data for decks and bulkheads.

Tube type		Bulkheads			Decks		
Tube size		A	B	F	A	B	F
Stuffing tube assembly	Part number M24235/18	-031	-032	-036	-091	-092	-096
Part numbers of components	Tube body (1 required) M24235/18	-151	-152	-156	-211	-212	216
	Gland nut (1 required) M24235/17	-241	-242	-246	-241	-242	-246
	Gland ring (1 required) M24235/17	-271	-272	-276	-271	-272	-276
Symbol number		1871	1872	1876	1941	1942	1946

TABLE 3A1-VIII. Reduced diameter swage type steel stuffing tube data for decks and bulkheads.

Tube type		Bulkheads			Decks		
Tube size		A	B	F	A	B	F
Stuffing tube assembly	Part number M24235/18	-001	-002	-006	-061	-062	-066
Part numbers of components	Tube body (1 required) M24235/18	-121	-122	-126	-181	-182	-186
	Gland nut (1 required) M24235/09	-061	-062	-066	-061	-062	-066
	Gland ring (1 required) M24235/09	-181	-182	-186	-181	-182	-186
Symbol number		1821	1822	1826	1911	1912	1916

METHOD 3B1

CABLE PENETRATIONS VIA MCP'S

1. SCOPE.

1.1 Scope. This method identifies MCP insert block sizes used to pass fiber optic cables through decks and bulkheads. The methods for installation of the MCP and insert blocks is the same as those specified for electrical cables in DOD-STD-2003-3. These installation methods are not repeated in this standard but they are identified in paragraph 5 in this part of this standard.

2. REQUIRED EQUIPMENT AND MATERIALS. (Not applicable.)

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed during the passing of fiber optic cables through the installed MCP's.

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of bare fibers as they may be razor sharp. Wash your hands thoroughly after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

Step 1 - Select MCP insert blocks from those shown in table 3B1-I.

TABLE 3B1-I. MCP data and insert block sizes for fiber optic cable.

Cable type	4-Fiber	8-Fiber	36-Fiber
Cable O.D. mm (inches) nominal	8.1 (0.32)	11.1 (0.44)	20.8 (0.82)
Primary insert block part number M24705/1-BN	1508	2011	3021
Alternate insert block part number M24705/1-BN	2008	N/A	N/A

NOTE: This draft, dated 15 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-4A(SH)

SUPERSEDING
MIL-STD-2042-4(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CABLEWAYS)

(PART 4 OF 6 PARTS)

AMSC N/A AREA GDRQ

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

CONTENTS

CONTENTS

1. SCOPE

1.1 Scope. This standard provides detailed methods for installing fiber optic cable cableways and cable protection on surface ships and submarines.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. When there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Standards. The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

DOD-STD-2003-4 - Electric Plant Installation Standard Methods for Surface Ships and Submarines (Cableways).

MIL-STD-2042-1 - Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Cables)(Part 1 of 6 Parts).

MIL-STD-2042-3 - Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Cable Penetrations)(Part 3 of 6 Parts).

MIL-STD-2042-6 - Fiber Optic Cable Topology Installation Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWINGS

NAVSEA Drawing - 803-5184182 Passive Fire Protection Insulation - Installation Details.
- 302-2146949 Electronics/Electrical Installation Methods.

- 302-4456087 Electronics/Electrical Installation Methods.

(Copies of documents should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, outlets, trunk and local cables and the connectors and splices used to interconnect the trunk and local cables.

3.3 Installing activity. An installing activity is any military, commercial, or industrial organization involved with the installation of fiber optic cable topologies aboard Naval ships.

3.4 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.5 Normal channel. A normal channel is an allocated and used active link between system equipment that has a designated active backup link.

3.6 Non redundant channel (NRC). A non redundant channel is any allocated and used active link that has no system required backup link.

3.7 Alternate channel. An alternate channel is the allocated and used backup link for a normal channel.

3.8 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment, or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.9 End user equipment. End user equipment refers to any cabinet, case, panel, or device that contains components that are either the origin or destination of an optical signal.

3.10 Minimum bend diameter. The minimum bend diameter of a fiber optic cable is the diameter at which the cable can be bent without degrading optical performance. The short term bend diameter applies during handling and installing; the long term bend diameter applies to the completed installation.

3.11 Authorized approval. Authorized approval is written approval from the cognizant Government activity.

3.12 Outlet. An outlet is a small termination box used to break out a local cable from an interconnection box to one or more equipments in a compartment or area.

4. GENERAL REQUIREMENTS

4.1 Location of fiber optic cable runs. Fiber optic cable shall be located to avoid physical interference with electric cables and equipment and to minimize risk of battle damage. Cable runs shall be located so that fiber optic cables will not be disturbed by disassembly or removal of machinery, including the removal of bolted or welded equipment removal plates. Fiber optic cables may be run in cableways with electric power and signal cables. However, fiber optic cables should not be installed in cableways with armored cables unless no feasible alternative routing exists. If fiber optic cables must be installed in the same cableways as armored cables, additional precautions must be taken during installation to prevent mechanical damage (see 4.2). Fiber optic cable shall not be run through bilge areas unless such routing is necessary to provide survivability through redundant signal paths. In such cases, suitable cable protection shall be provided (see 4.1.7). Where the installing activity (see 3.3) is responsible for the design of the fiber optic topology cableways, it shall be as specified herein.

4.1.1 Main fore and aft cable runs.

4.1.1.1 Surface ships. Main fore and aft cable runs shall be routed as follows. Main fore and aft cable runs shall be located port and starboard and high and low in the ship. The lower cableways shall be through the machinery spaces and corresponding platform decks, while the upper cableways shall be under the main deck. This location of cableways is designed to provide a quadrangular pattern to allow maximum athwartship and vertical separation of cables for systems requiring alternate signal paths for reliability and survivability. The athwartship separation shall be achieved by locating the cable runs not greater than 1.8 m (6 ft) from the most outboard structure (2.4 m (8 ft) from curved structure) on the respective sides of the ship. The vertical separation shall be achieved by separating the cable runs by not less than two decks. Where two deck separation is not possible due to ship geometry, a minimum of one deck separation shall be provided. The longitudinal separation distance between vertical or athwartship cable runs shall be not less than 19.7 m (65 ft) in the hull and 12.1 m (40 ft) in the superstructure.

4.1.1.2 Submarines. Main fore and aft cable runs shall be located near the inner surface of the pressure hull in a quadrangular pattern to allow maximum athwartship and vertical separation of cables for systems requiring alternate signal paths for reliability and survivability.

4.1.2 Vertical cable runs. Vertical cable runs shall be organized on the basis of the fore and aft or athwartship separation of main cable runs and equipment served.

4.1.3 Fiber optic local cable runs. Fiber optic local cable runs shall be routed from the end user equipment (see 3.9) to the interconnection box that services that equipment. Systems that have redundant local cables shall have these local cables routed to separate interconnection boxes, wherever practical, unless otherwise specified in the drawings. These separate interconnection boxes shall be separated in the athwartship direction to the maximum extent possible and vertically by not less than two decks or by a horizontal distance of 19.7 m (65 ft) in the hull or 12.2 m (40 ft) in the superstructure. Redundant local cable runs shall be survivably separated as described in 4.1.1 except when they are within 18.2 m (60 ft) of the equipment.

4.1.4 Cable runs with special requirements.

4.1.4.1 Control from more than one location. Where equipment is controlled from more than one location, the cables from each location shall be routed in separate cableways.

4.1.4.2 Control by two cables from one location. Where equipment is controlled by two cables from one location and each cable performs the same function, the two cables shall be routed in separate cableways. These cableways shall come together only at the system equipment they service.

4.1.4.3 Cables containing redundant fibers. Where interconnection boxes are connected by cables containing NRC fibers and cables containing the redundant fibers to those NRC fibers, the cables shall be routed in separate cableways. These cableways shall come together only at the interconnection boxes they service.

4.1.5 Protection of cable runs.

4.1.5.1 Protection from battle damage. Protection afforded by ship structure shall be used to the greatest extent practical. Cable runs shall not be located on the exterior of deckhouses or similar structures above the main deck (including the island structure of aircraft carriers), except where necessary because of the location of the equipment served or because of structural interference or avoidance of hazardous conditions or locations.

4.1.5.2 Protection from mechanical damage. Cable runs subject to mechanical damage because of their proximity to areas frequented by personnel or by potential impact by loose equipment during shock shall be protected by metal casings. Cableways in areas where their misuse as steps or hand holds would cause damage shall be protected. Protective plates shall be installed over the cableways in all passages where cables might be stepped on. At hatch openings and in trunks where objects are raised and lowered, cableways shall be protected by steel casings. To protect the outer jacket of cables from being cut, channel rubber shall be used with banding straps as follows:

a. For each banding strap of a vertical cableway.

b. For each banding strap at a cableway bend, including breakout bends.

c. For fiber optic cables in direct contact with the banding strap.

Where fiber optic cables are run outside of the main cableways, they shall be supported by preformed brackets or hose clamp cable retention devices featuring integral rubber inserts. The supports shall be spaced along the cable such to minimize stress and strain on the cable.

4.1.5.2.1 Protection in cargo spaces. Cable runs shall be routed outside cargo spaces wherever practical. Where routing through cargo spaces is unavoidable, cableways shall be protected from mechanical damage, including damage due to shifting of cargo.

4.1.5.2.2 Protection in riser boxes and multiple cable penetrators. Topside or explosion proof deck penetrations for cable runs with three or more cables shall be accomplished using riser boxes with stuffing tubes penetrations. Watertight deck penetrations in locations not open to the weather for cable runs with three or more cables shall be accomplished using riser boxes with multiple cable penetrators (MCP's) or deck mounted MCP's with shields for mechanical protection. Nonwatertight deck penetrations for cable runs with three or more cables shall be protected using a riser tube or welded collar. Where cable runs with fewer than three cables pass through a deck, kickpipes or swage tubes shall be installed in accordance with Part 3 of this standard.

4.1.5.2.3 Protection on an oiler weather deck. Cable runs routed on the weather deck of oilers shall be protected by a substantial open bottom steel enclosure. Cable runs routed alongside or under the weather deck catwalks shall be completely enclosed in a steel enclosure, the bottom section of which shall consist of a removable steel plate. Enclosures shall be constructed so as to permit periodic inspection and maintenance of cables and hangers.

4.1.5.3 Protection from the weather. Cable runs in the weather shall be kept to the minimum practical length to provide service to the equipment. Where possible, cables to equipment on masts, staffs, and yardarms shall be installed within the masts, staffs, and yardarms.

4.1.5.4 Protection from excessive heat. Cable runs in locations subject to excessive heat or risk of fire shall be avoided. Where required, heat insulating barriers shall be installed. Cable runs shall not be installed adjacent to machinery, piping, or other surfaces having an exposed surface temperature greater than 65 degress Celcius (°C) [149 degrees Fahrenheit (°F)]. Cable runs shall not be routed over boilers, in the upper portions of firerooms, in passageways at the aft end of aircraft catapults, or in locations where they will be exposed to hot stack gases.

4.1.5.5 Protection from excessive moisture. Cable runs shall not be routed through locations where they may be subjected to excessive moisture. Where cable routing near firemain, water, steam, oil or other piping is unavoidable, dripproof shields shall be provided for protection. Where cable runs must be routed in spaces subject to flooding, they shall be installed as high as practical within the space.

4.1.6 Cable runs through bilges, submerged spaces and voids. Cable runs through bilges and spaces that would normally be submerged, except for cables in the sonar dome, shall be enclosed in a single pipe in a manner similar to that for cables passing through tanks. Cable runs in voids and other dead air spaces shall be avoided. If it is not practical to avoid cable runs in such spaces, cables shall be installed only in those spaces which are not provided with a means for flooding. Cable runs shall be supported clear of decks and bulkheads to avoid condensate which might form on such surfaces.

4.1.7 Cable runs in hazardous locations. Cable runs may be routed in hazardous locations such as magazines, battery shops and flammable liquid storage areas.

4.1.8 Cable runs in hangar spaces (aircraft carriers). Horizontal cable runs shall not pass through hangar spaces. Vertical cable runs, such as those from the second deck to the gallery or flight deck levels shall be grouped to

the greatest extent practical, to reduce the number of protective casings required, and shall be protected from fire in accordance with the methods in 5.1.4.

4.1.9 Cable runs to gun mounts and directors. Cable runs to gun mounts and directors shall be routed from the deck below through the center column and located such to avoid the possibility of chafing. Watertight integrity, where required, shall be maintained. In compartments containing hydraulic systems, the cable installation shall not impair the airtightness or watertightness of decks and bulkheads forming the boundaries of the compartment.

4.1.10 Cable runs to rotating missile launchers. Cable runs to rotating missile launchers shall comply with drawings furnished by NAVSEA.

4.2 Installation of fiber optic cables in cableways.

4.2.1 Cable pulling. Fiber optic cables shall be installed by feeding the cable through the cableway in a segment by segment fashion for the entire route and then securing it into the cableways. Block and tackle, chain falls, or other mechanical devices shall not be used to pull fiber optic cable. The cable shall be pulled to avoid kinking, twisting, sharp bending (see 4.2.2), or stretching by applying excessive pulling force. The fiber optic cable should be monitored at all bend points and at multiple points on long straight runs to ensure that the cable does not encounter sharp objects. It is recommended that the cable be pulled slowly, so that if it does get caught, it will be readily noticeable and cable pulling can be stopped before any damage occurs.

4.2.2 Cable pulling in armored cable cableways. Cableways containing armored cable should be avoided where possible. Where installation of fiber optic cables into cableways containing armored cable cannot be avoided, additional personnel shall be used to monitor during pulling due to the increased possibility for mechanical damage to the fiber optic cable.

4.2.3 Cable bend diameter. During handling and installation in cableways, cable bends shall not violate the minimum short term bend diameter (see 3.10) of eight times the cable outside diameter. The completed installation shall not violate the minimum long term bend diameter of sixteen times the cable outside diameter. Special handling procedures are required during installation of cables at or below temperatures of 2°C (36°F). If cable must be installed when its temperature is 2°C (36°F) or lower, that portion of the cable that must be bent during installation shall be warmed thoroughly using a heat gun (or equivalent) before installing the cable in the cableway.

CAUTION: Prolonged exposure of the cable jacket to a temperature above 160°C (320°F) could cause damage to the cable jacket.

4.2.4 Installed cable slack. Cables shall be installed in accordance with the following:

a. Sufficient slack shall exist to allow for deflection of bulkheads.

b. The sag between hangers shall be uniform for each row of cables so that clearance between rows will be the same throughout the cable run.

c. Where cables spread out to enter bulkhead stuffing tubes or MCP's, bends shall have a liberal sweep to provide as much flexibility as practicable.

d. Cables having only a minimum spread where they pass through bulkhead stuffing tubes shall have enough slack to give them the same flexibility as other cables in the group.

e. Cables from equipment shall enter cableways in a curve of sufficient radius to prevent transmission of stresses to the equipment during severe cableway deflection.

f. Cables entering or connected to equipment shall have additional slack as specified in Part 2 of this standard.

g. Cables crossing expansion joints shall have slack allowance at such points not less than equal to the maximum movement of the expansion joints.

4.2.5 Cable placement in cable hangers. Fiber optic cables shall not be run through the cross-tier mounting holes of cable hanger vertical support channels. Where fiber optic cables are to be mixed with electric cables in the same cableway, the fiber optic cables shall be installed last and be run on top of the electric cables where possible, and

shall be located in the center of the cableway. If electric cables are installed on top of fiber optic cables, they shall be installed in accordance with 4.3.

4.2.6 Installation on bulkheads and overheads. Installation of cables on the overhead and on bulkheads shall be in accordance with the methods described herein. Cables for vital systems such as interior communications and weapons control systems shall not be secured to the overhead, or to shell planking, or plating, or to ballistic bulkheads unless otherwise specified (see 3.11).

4.2.6.1 Cable hangers and supports. Cable hangers and supports shall be in accordance with DOD-STD-2003-4 and as specified herein. Only steel hangers and supports shall be used where the deck or bulkhead is steel. Aluminum or steel hangers and supports shall be used where the deck or bulkhead is aluminum; however, if aluminum hangers and supports are used, a steel hanger and support shall be installed not less than every 1.8 m (6 ft). In those locations where the ship structure is aluminum, details of the methods for attaching steel cable hangers to the structure shall be in accordance with NAVSEA Drawing 803-5184182.

4.2.7 Installation on ballistic structures. Attachment of cables and supports to ballistic structures shall be in accordance with the methods described herein and the following:

a. First preference shall be given to routing cables on the inboard or after bulkheads in the forward half of the ship, and on the inboard and forward bulkheads in the after half of the ship.

b. Second preference shall be given to routing cables on channels, or in cable racks on angles, attached to overhead deck beams.

c. Cables shall not be routed on the outboard or forward bulkheads in the forward half of the ship, nor on the outboard or after bulkheads in the after half of the ship, when the plating is 244 kilograms per square meter (kg/m^2) [50 pounds per square foot (lb/ft^2)] or heavier.)

4.2.8 Double banking of cable. For surface ships, only one row of cables shall be installed on a cable hanger tier. Where space is limited, and if authorized approval is obtained (see 3.11), double banking (two rows maximum) of cables on tiers will be permitted. The requirements of 4.1.5.2 and the restraints of 4.2.1 through 4.2.5 shall be observed when double banking fiber optic cables with armored and unarmored electric cables.

4.2.9 Cable retention. Retention of cables on supports can be accomplished by the use of retainers such as contour straps, soft iron flat bars bent over the cables, semi-contour straps or angle-iron retainers. Non toxic strips or channel material shall be used with semi-contour straps, bars, and angle retainers to reduce cable damage, distortion, and chafing (see 4.1.5.2). Cable retention is required at every hanger on vertical cable runs. Cable straps shall be omitted on horizontal cable runs except as follows:

a. Where the hanger has no side brackets.

b. At those locations where the cable runs change direction or pass through beams or bulkheads.

c. Where four consecutive hangers would not require straps. In this case, a minimum of one strap shall be installed on every fourth hanger.

d. Where the horizontal cable supports have multiple tiers.

4.2.10 Cable tags. All permanently installed cables shall be tagged to each point of connection, and on both sides of decks and bulkheads except as follows:

a. Where through cable runs within a compartment are easily traced (such as a vertical run between decks), a single tag will suffice.

b. For cables with both points of connection within a compartment and which can be readily traced, a single tag will suffice.

c. Where compartments are subdivided by internal bulkheads or where machinery or installed equipment makes tracking of cable runs difficult, additional tags shall be provided.

d. For multiple cable penetrations of decks and bulkheads (main cableways), individual cable tags can be omitted, and in lieu thereof, an identification plate shall be installed adjacent to the cableway penetration area showing each cable designation in the order of location in the penetration area.

Cable tags and marking shall be as specified in Part 1 of this standard.

4.2.11 Dead-ended cable. Cable installed through error or rendered useless as a result of modifications shall be removed where practical. Vacated and unused penetrations shall be sealed by methods that satisfy the tightness requirements of the structure penetrated.

4.3 Electric cable installation over fiber cables. The installation of electric cables over fiber optic cables should be avoided where possible. Where installation of electric cables over fiber optic cables cannot be avoided, either protective coverings shall be placed over the fiber optic cables during the electric cable installation or personnel shall monitor the fiber optic cable during the electric cable pull to minimize damage to the fiber optic cable.

4.4 Cableways. Cableways shall be in accordance with DOD-STD-2003-4 and as specified herein.

4.4.1 Spare cable allowance. In the organization of principal cableways, spare cable space of approximately 20 percent of that to be occupied by the final combined electric and fiber optic cable installation (as known at the time of delivery of the ship) shall be reserved on tier bars of cable hangers and in electric and fiber optic cable penetration areas for future cable installations. The additional cable space may consist of unused hangers or a combination of unused hangers and space available on used hangers, assuming that double banking will be allowed for future fiber optic cable (see 4.2.8). During the planning phase, the Contractor shall provide cableway space in excess of the required 20 percent, in order to accommodate electric and fiber optic cables added as a result of design development occurring during the construction period.

4.5 Fiber optic cable topology test. The fiber optic cable topology shall be tested for continuity and loss during various stages of installation in accordance with Part 6 of this standard.

4.6 Safety precautions. The following safety precautions apply:

a. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

b. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

c. Wash hands after handling bare fibers.

5. DETAILED REQUIREMENTS

5.1 Cableways. Cableways for fiber optic cables shall be the same as those for electrical cables given in DOD-STD-2003-4 and as specified herein. These methods will not be repeated in this standard; however, they are identified and listed here to aid the user in rapidly locating the applicable method in DOD-STD-2003-4 to be used for fiber optic cable runs.

5.1.1 Cableways (submarines). The following methods and drawings shall be used to install cableways on submarines only:

DOD-STD-2003-4, Figures 4A1 through 4A14 and
NAVSEA Drawings 302-2146949 and 302-4456087

5.1.2 Cableways (surface ships). The following methods shall be used to install cableways on surface ships only:

DOD-STD-2003-4, Figures 4B1 through 4B55

5.1.3 Cableways (general). The following methods shall be used to install cableways on both submarines and surface ships:

DOD-STD-2003-4, Figures 4C1 through 4C27

5.1.4 Cable protection. The following methods shall be used to protect cables from mechanical or environmental damage:

DOD-STD-2003-4, Figures 4D1 through 4D10

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cableway requirements and cable protection methods depicted in this standard are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1).

6.3 Subject term (key word) listing.

Cable runs
Protection of cables
Cable tags
Installation of fiber optic cable in cableways

Preparing activity:
NAVY - SH
(Project GDRQ-NXXX)

NOTE: This draft, dated 15 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-5A(SH)

SUPERSEDING
MIL-STD-2042-5(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (CONNECTORS AND INTERCONNECTIONS)

(PART 5 OF 6 PARTS)

AMSC N/A AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

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CONTENTS

1. SCOPE

1.1 Scope. This standard provides detailed methods for installing fiber optic cable connectors and interconnecting devices.

1.1.1 Applicability. These criteria apply to installations on specific ships when invoked by the governing ship specification or other contractual document. They are intended primarily for new construction; however, they are also applicable for conversion or alteration of existing ships. The rapidly changing state of the art in fiber optic technology makes it essential that some degree of flexibility be exercised in enforcing this document. Where there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications of existing methods to NAVSEA 03K12 for approval prior to implementation.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the Department of Defense Index of Specifications and Standards (DODISS) and supplements thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-S-24623	- Splice, Fiber Optic Cable, General Specification for (Metric).
MIL-A-24792	- Adhesive, Epoxy, Two Part, Fiber Optics.
MIL-A-24793	- Adhesive, UV Curable, One Part, Fiber Optics.
MIL-M-24794	- Material, Index Matching, Fiber Optics.
MIL-C-28876	- Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini, General Specification for.
MIL-T-29504	- Termini, Fiber Optic Connector, Removable, General Specification for.
MIL-C-83522	- Connectors, Fiber Optic, Single Terminus, General Specification for.

STANDARDS

MILITARY

MIL-STD-2042-1	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Cables)(Part 1 of 6 Parts).
MIL-STD-2042-2	- Fiber Optic Cable Topology Installation, Standard Methods for Naval Ships (Equipment)(Part 2 of 6 Parts).
MIL-STD-2042-6	- Fiber Optic Topology Installation, Standard Methods for Naval Ships (Tests)(Part 6 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWINGS

NAVSEA Drawing	- 6872811 Tool Kit, MIL-C-83522, Fiber Optic, Navy Shipboard.
	- 6872812 Tool Kit, MIL-S-24623, Fiber Optic, Navy Shipboard.
	- 6872813 Tool Kit, MIL-C-28876, Fiber Optic, Navy Shipboard.

(Copies of documents should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2 - Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-440 - Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, outlets, trunk and local cables and the connectors and splices used to interconnect the trunk and local cables.

3.3 Installing activity. An installing activity is any military, commercial, or industrial organization involved with the installation of fiber optic cable topologies aboard Naval ships.

3.4 End user equipment. End user equipment refers to any cabinet, case, panel, or device, that contains components that are either the origin or destination of an optical signal.

3.5 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.6 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment, or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.7 Optical fiber cable component (OFCC). An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket.

3.8 Outlet. An outlet is a small termination box used to break out a local cable from an interconnection box to one or more equipments in a compartment or area.

3.9 Authorized approval. Authorized approval is written approval from the cognizant Government activity.

4. GENERAL REQUIREMENTS

4.1 Fiber optic cable interconnection. Fiber optic cable interconnection within the fiber optic cable topology (see 3.2) shall be made by fiber optic connectors or fiber optic splices.

4.1.1 Interconnection component selection. The interconnection component shall be that referenced in ship specifications and drawings. In those instances where the installing activity (see 3.3) is responsible for determining the correct components, they shall be selected in accordance with 4.2 and 4.3. Termination of the various categories of fibers shall be in accordance with Part 1 of this standard.

4.2 Fiber connectors. Fiber optic connectors shall be as follows:

a. Single terminus (light duty) connectors in accordance with MIL-C-83522/16 shall be used to interconnect two optical fiber cable components (OFCC's) inside an interconnection box or equipment.

b. Multiple terminus (heavy duty) connectors in accordance with MIL-C-28876 shall be used for end user equipment (see 3.4) hookup. Plug connectors with inserts configured for pin termini shall be used on shipboard cabling. Receptacle connectors with inserts configured for socket termini shall be used on equipments. Plug connectors shall have backshells with integral strain relief. Receptacle connectors should be configured without backshells. Receptacle connectors should be configured with insert retention nuts.

4.2.1 Installation. Connectors shall be installed on cables in accordance with the methods herein and as follows:

a. The hookup configuration of a heavy duty connector (pin destinations) shall be in accordance with the approved drawings.

b. Where a heavy duty connector is installed on the end of a cable, the optical fibers shall be connected to pin termini in a plug style connector. Every terminus position shall have either an optical or dummy terminus in accordance with MIL-T-29504/3, /14 or /15.

c. Only receptacle style heavy duty connectors shall be used on equipment. Only socket type termini in accordance with MIL-T-29504/15 shall be used in receptacle style heavy duty connectors.

4.3 Fiber optic splices. Fiber optic splices shall be in accordance with MIL-S-24623/4. The mechanical splice is primarily used as an interconnection similar to the light duty connector in 4.2(a) except that the splice interconnection is less robust and typically induces less loss in the optical link. The method described herein applies to the mechanical splice used as a normal interconnection between cables.

4.3.1 Installation. Fiber optic splice ferrules shall be installed on buffered fibers in accordance with the methods herein and as follows:

a. The splice ferrules shall be mated, aligned and installed in the splice tray in accordance with the methods in Part 2 of this standard.

b. Splices shall be located only inside the interconnection box or equipment.

4.4 Tests. Following installation, testing of all components of the fiber optic cable topology shall be in accordance with Part 6 of this standard.

4.5 Safety precautions. The following safety precautions apply:

a. Observe all written safety precautions given in the methods of this standard.

b. Observe all warning signs on equipment and materials.

c. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

d. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

e. Wash hands after handling bare fibers or performing fiber terminations.

f. Ultraviolet (UV) safety glasses shall be worn when using the UV curing lamp.

5. DETAILED REQUIREMENTS

5.1 Heavy duty connector installation. Installation of the MIL-C-28876 heavy duty connector on fiber optic cable shall be in accordance with Method 5A1. There are three basic connector rear end configurations; with removable backshell, with non removable backshell, and with insert retention nut.

5.1.1 Heavy duty connectors with removable backshells. Connectors with removable backshells are described with the basic Military Part Numbers M28876/1, M28876/6, and M28876/11. These connectors do not contain an integral backshell with strain relief and must be assembled to a backshell during installation. Backshells with strain relief for use with these connectors are described with the basic Military Part Numbers M28876/27, M28876/28, and M28876/29. Method 5A1-1 shall be used to install the connector and the backshell on the cable for these connectors.

5.1.2 Heavy duty connectors with non-removable backshells. Connectors with non-removable backshells are described with the basic Military Part Numbers M28876/2, M28876/3, M28876/4, M28876/7, M28876/8, M28876/9, M28876/12, M28876/13, and M28876/14. These connectors contain an integral backshell with strain relief. Method 5A1-2 shall be used to install the connector on the cable for these connectors.

5.1.3 Heavy duty connectors with insert retention nuts. Connectors with insert retention nuts are also described with the basic Military Part Numbers M28876/1 and M28876/11. These connectors do not contain an integral backshell with strain relief and are not required to be assembled to a backshell during installation. These connectors are for use in situations where strain relief is not required (for example, the equipment side of a equipment fiber optic interface.) Method 5A1-3 shall be used to install the connector within the equipment for these connectors.

5.2 Light duty connector installation. Light duty connectors in accordance with MIL-C-83522/16 shall be installed on fibers in accordance with Method 5B1.

5.3 Mechanical (rotary) splice installation. Mechanical (rotary) splice ferrules shall be installed on fibers in accordance with Method 5C1. Assembly of the splice shall be in accordance with Method 2D1 in Part 2 of this standard.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

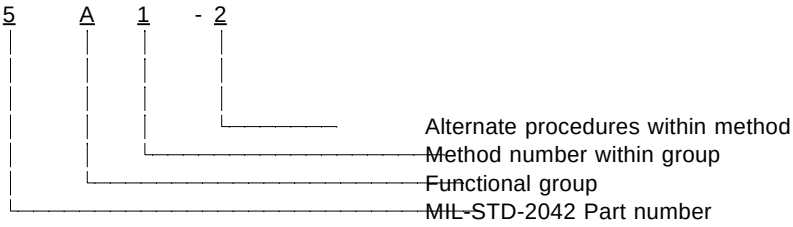
6.1 Intended use. The methods for installation of connectors and interconnections depicted in this standard are intended primarily for new construction; however, they are applicable for conversion or alteration of existing ships.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1).

6.3 Standard method designation. To simplify the usage of this standard, an alpha-numeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Multiple terminus connector installation
B: Single terminus connector installation
C: Mechanical splice ferrule installation

Then the designation system was completed as follows:



Thus, method 5A1-2 identifies the second alternate procedure within method 1 of group A in Part 5 (MIL-STD-2042-5) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Fiber optic cable interconnection
Fiber optic connectors
Fiber optic splices
Safety

Preparing activity:
NAVY - SH
(Project GDRQ-NXXX)

METHOD 5A1

MULTIPLE TERMINUS CONNECTOR INSTALLATION

1. SCOPE.

1.1 Scope. This method describes a procedure for installing MIL-C-28876 multiple terminus (heavy duty) connectors on fiber optic cable. Method 5A1-1 covers connectors with removable backshells, method 5A1-2 covers connectors with non-removable backshells, and method 5A1-3 covers connectors with insert retention nuts. (See paragraph 5.1 of this standard for more detail.)

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers or dispensing epoxy.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Avoid skin contact with epoxies.

d. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

3.2 Procedure I. Method 5A1-1 Installation of connectors with removable backshells. This method shall be used to install connectors with part numbers M28876/1, M28876/6 and M28876/11 configured without insert retention nuts and backshells with part numbers M28876/27, M28876/28 and M28876/29 onto fiber optic cables.

3.2.1 Equipment and materials. The equipment and materials in table 5A1-I shall be used to perform this procedure:

TABLE 5A1-I. Equipment and materials.

Description	Quantity
Wipes (NAVSEA DWG 6872813-22 or equal)	As required
Ruler	1
Alcohol bottle with alcohol/2-propanol or equal (sealable type)	1
Canned air or compressed air	As required
Cable jacket stripping tool (NAVSEA DWG 6872813-8 or equal)	1
Masking tape	As required
Kevlar shears (NAVSEA DWG 6872813-16 or equal)	1
OFCC strip tool (NAVSEA DWG 6872813-10 or equal)	1
Safety glasses	1
Buffer strip tool (NAVSEA DWG 6872813-9 or equal)	1
Cleaning wire (NAVSEA DWG 6872813-32 or equal)	As required
Epoxy (MIL-A-24792)	As required

TABLE 5A1-I. Equipment and materials - continued.

Description	Quantity
Syringe with dispensing needles (NAVSEA DWG 6872813-27 or equal)	As required
Crimp tool (NAVSEA DWG 6872813-17 or equal)	1
Razor blade	1
Cure adapters (NAVSEA DWG 6872813-19 or equal)	As required
Curing oven (NAVSEA DWG 6872813-19 or equal)	1
Cable stand (NAVSEA DWG 6872813-19 or equal)	1
Cable stand ring (NAVSEA DWG 6872813-19 or equal)	1
Cable clip (NAVSEA DWG 6872813-19 or equal)	1
Cleaver (NAVSEA DWG 6872813-7 or equal)	1
Polishing paper (5 µm aluminum oxide, foam backed) (NAVSEA DWG 6872813-24 or equal)	As required
Polishing tool ceramic termini (NAVSEA DWG 6872813-18 or equal)	1
Terminus insertion tool (NAVSEA DWG 6872813-2 or equal)	1
Terminus insertion tool 90° (NAVSEA DWG 6872813-15 or equal)	1
Glass polishing plate (NAVSEA DWG 6872813-3 or equal)	1
7X eye loupe	1
Polishing paper (1 µm aluminum oxide, mylar backed) (NAVSEA DWG 6872813-23 or equal)	As required
Water bottle (sealable type)	1
Terminus removal tool (NAVSEA DWG 6872813-6 or equal)	1
Optical microscope 400X (NAVSEA DWG 6872813-28 or equal)	1
Alignment sleeve insertion and removal tool (ceramic termini)(NAVSEA DWG 6872813-4 or equal)	1
Loctite or equal	As required
"O"-ring lubricant (Bray Cote 609 or equal)	As required
Adjustable wrench	1
Backshell grip	1
Protective caps (plastic)	As required

CAUTION: Throughout the termination process, cleanliness is critical to obtaining a high optical quality connector. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the connector parts.

NOTE: Verify that the epoxy shelf life has not expired. Do not use epoxy with an expiration date that has passed.

3.2.2 Cable and fiber preparation.

Step 1 - Ensure the cable is the correct type as specified on the applicable cable diagram.

Step 2 - Measure the cable to the required length. Then add sufficient slack to allow for at least two reterminations [191 mm (7.5 inches) of slack should be sufficient for one retermination].

Step 3 - Clean the outer cable jacket that will be in contact with the connector and backshell with a wipe dampened with alcohol and blow it dry with air.

NOTE: Keep the cable and connector parts free from oil, dirt and grease throughout the installation procedure. If cleaning is necessary, use a wipe dampened with alcohol and blow the part dry with air.

Step 4 - Slide the backshell parts onto the cable in the order indicated below (see figure 5A1-1).

a. Backnut

b. "O"-ring

c. Spacer

d. Ferrule (kevlar grip)

e. Sheath (ensure "O"-rings are in place)

f. Backshell body

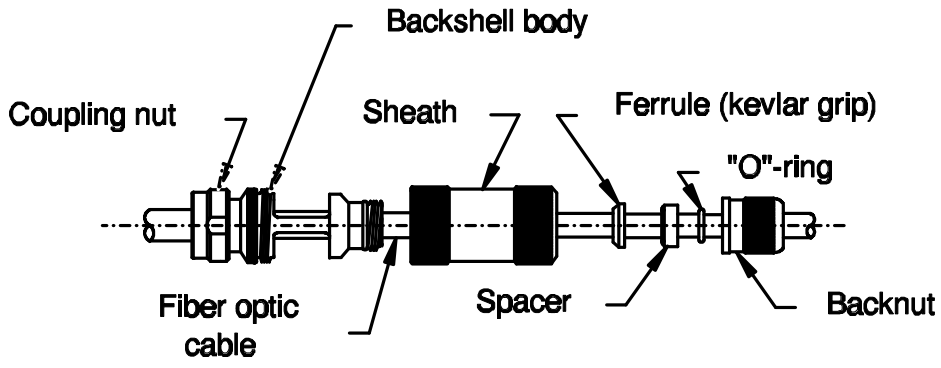


FIGURE 5A1-1. Backshell parts on the cable (straight backshell).

Step 5 - Mark the cable jacket approximately 191 mm (7.5 inches) from the end and strip back the outer cable jacket to the mark using the cable stripper. Fold back the kevlar strength members and temporarily tape them to the cable outer jacket.

CAUTION: Do not cut or nick OFCC jackets.

Cut off the exposed central member and any fillers using the kevlar shears.

Step 6 - Remove any water blocking material, clean the OFCC's using a wipe dampened with alcohol and blow them dry with air.

Step 7 - Trim the OFCC's to dimension A in table 5A1-II using the kevlar shears (see figure 5A1-2).

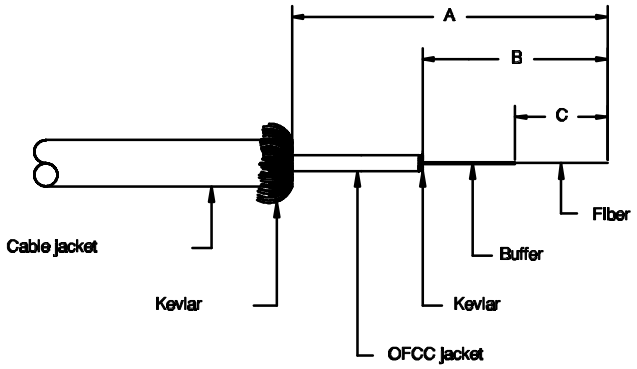


FIGURE 5A1-2. Cable stripping dimensions.

Step 8 - Feed each OFCC into a crimp sleeve and slide the sleeve back from the end of the OFCC. (NOTE: Only use crimp sleeves intended for termini. Do not use crimp sleeves intended for other types of connectors. The standard crimp sleeve for the terminus may be oriented in either direction.)

Step 9 - Remove the OFCC jackets back to dimension B in table 5A1-II using the OFCC stripper and trim the OFCC kevlar so that approximately 3 mm (0.12 in) extends past the OFCC jacket.

TABLE 5A1-II. Cable stripping dimensions.

Connector shell size	Backshell configuration	Dimensions mm (in)					
		Long Backshell			Short Backshell		
		A	B	C	A	B	C
13	Straight	135 (5.3)	30 (1.2)	19 (0.75)	117 (4.6)	30 (1.2)	19 (0.75)
	45°	150 (5.9)	30 (1.2)	19 (0.75)	130 (5.1)	30 (1.2)	19 (0.75)
	90°	150 (5.9)	30 (1.2)	19 (0.75)	130 (5.1)	30 (1.2)	19 (0.75)
15	Straight	161 (6.3)	30 (1.2)	19 (0.75)	135 (5.3)	30 (1.2)	19 (0.75)
	45°	155 (6.1)	30 (1.2)	19 (0.75)	130 (5.1)	30 (1.2)	19 (0.75)
	90°	155 (6.1)	30 (1.2)	19 (0.75)	130 (5.1)	30 (1.2)	19 (0.75)

Step 10 - **WARNING:** Wear safety glasses when removing the fiber buffer and coating to avoid possible eye injury.

Remove the fiber buffers and coatings back to dimension C in table 5A1-II using the buffer stripper. Remove the buffer and coating in small sections (approximately 6 mm (0.25 in) at a time.) (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

Step 11 - **CAUTION:** The uncoated fiber is in its most vulnerable state. Take extreme care not to damage the fiber. Breakage of any one fiber from this point until the connector is completely assembled

will require repetition of this and the following steps in order to maintain approximately equal length of all the fibers in the cable.

Remove any residual coating material from the bare fibers with a wipe dampened with alcohol. Wipe only once from the end of the buffer towards the end of the fiber. (NOTE: Do not repeatedly wipe the bare fiber as this will weaken the fiber.)

3.2.3 Installation of the termini onto the fibers.

NOTE: This procedure describes the process for installing ceramic termini onto either multimode or single-mode fibers. The termini use epoxy to secure the fiber and a crimp sleeve to capture the kevlar strength members of the OFCC's.

Step 1 - Turn on the curing oven so that it attains the proper temperature before the termini are placed within it (approximately 20 minutes).

Step 2 - Inspect the terminus and verify that the ferrule hole is free and clean of dirt. This can be accomplished by holding the front of the terminus up to a light and verifying that the light is visible from the rear of the terminus. If light cannot be seen through the terminus, push music wire through the terminus hole to clear it. Then blow dry air through the hole to remove any debris.

Step 3 - Remove the divider from a 2-part epoxy package and mix the two parts together until the epoxy is a smooth uniform color (see figure 5A1-3). The epoxy can be mixed by either repeatedly rolling the divider over the package or gently sliding the divider over the package.

NOTE: Alternatively, the epoxy may be mixed by massaging the epoxy package by hand.

CAUTION: Do not introduce large air bubbles into the epoxy during the mixing process. Large air bubbles in the epoxy can lead to connector failure during temperature extremes.

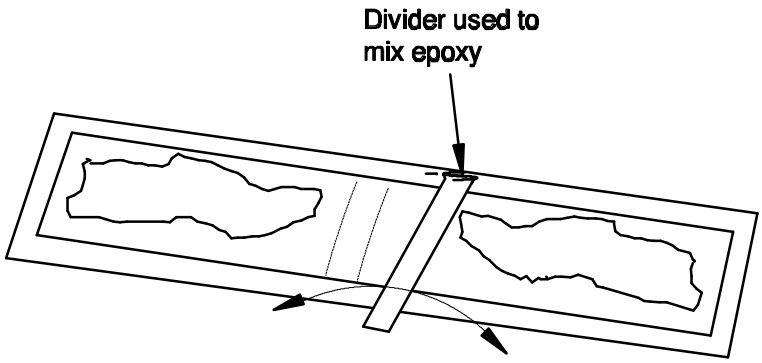


FIGURE 5A1-3. Mixing the epoxy.

Step 4 - Install the syringe tip on the syringe, remove the plunger, and squeeze the epoxy into the syringe. Replace the plunger.

Step 5 - **WARNING:** Wear safety glasses while dispensing the epoxy to avoid possible eye injury.

Remove air pockets in the syringe by holding the tip of the syringe upward and dispensing epoxy onto a wipe until it runs free and clear.

Step 6 - Slide the terminus, rear first, onto the syringe tip (see figure 5A1-4). Keeping the syringe vertical, depress the plunger and slowly inject epoxy into the terminus until it escapes out of the ferrule, forming a very small bead. (NOTE: Do not overfill. Be extremely careful not to get epoxy on the pin spring or other terminus moving parts.)

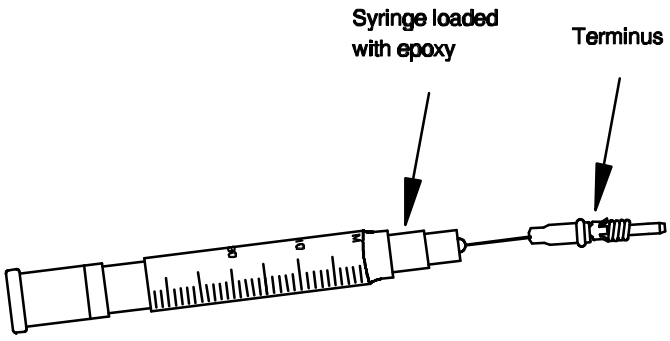


FIGURE 5A1-4. Injecting epoxy into the terminus.

Step 7 - Withdraw the syringe from the terminus. Maintain some pressure on the plunger as the syringe is withdrawn so that the terminus is completely filled with epoxy. Using a wipe dampened with alcohol, wipe away any epoxy on the outer diameter of ferrule without disturbing the epoxy bead.

NOTE: Alternatively, the terminus may be completely filled by maintaining a light pressure on the syringe plunger and allowing the epoxy to push the terminus off of the syringe tip.

Step 8 - Feather the kevlar evenly around the fiber and insert the fiber into the rear of the terminus (see figure 5A1-5). Gently work the fiber through the terminus until the buffer seats against the rear of the ferrule. The OFCC jacket should come up to the rear of the terminus and the kevlar should surround the rear of the terminus. Once inserted, do not allow the fiber to slip back.

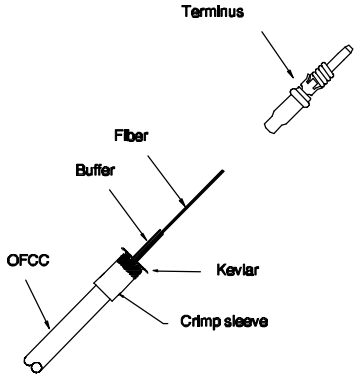


FIGURE 5A1-5. Inserting the fiber into the terminus.

Step 9 - Slide the crimp sleeve over the kevlar and crimp it to the rear of the terminus using the crimp tool. (NOTE: A small amount of epoxy may be added on the kevlar near the rear of the terminus before the crimp sleeve is installed. However, no epoxy should be visible once the crimp sleeve is installed.)

Step 10 - Verify that the kevlar does not protrude excessively from under the crimp sleeve. Excessive kevlar protrusion will cause the terminus to not seat properly in the finished connector. If excessive kevlar protrudes from under the crimp sleeve, trim it back using a razor blade.

Step 11 - Verify that there is a small amount of epoxy around the fiber where it protrudes from the ferrule. If it is found that there is no small bead of epoxy on the terminus tip, carefully add a small amount of epoxy around the fiber. (NOTE: There should only be a small amount of epoxy around the fiber to support it later during the polishing process. If too much epoxy is around the fiber during the curing process it may cause the fiber to crack.)

Step 12 - Using a wipe dampened with alcohol, carefully wipe away any excess epoxy on the fiber that is more than 2 mm (0.08 in) from the ferrule tip surface.

Step 13 - Insert the terminus into the cure adapter until it snaps into place (see figure 5A1-6).

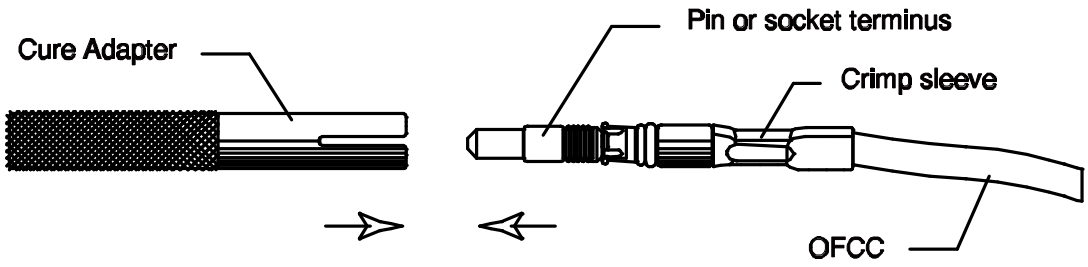


FIGURE 5A1-6. Inserting a terminus in a cure adapter.

Step 14 - Repeat steps 2 through 13 for each fiber to be terminated.

Step 15 - Place the cure adapters in the curing oven, and position the cable vertically over the oven using the cable stand, cable stand ring and cable clip (see figure 5A1-7). Cure the epoxy for a minimum of 10 minutes (maximum of 30 minutes) at 120°C (248°F). (NOTE: When the cable is positioned above the terminus, make sure that no bends are placed in the OFCCs. Each OFCC should enter the terminus parallel to the terminus.)

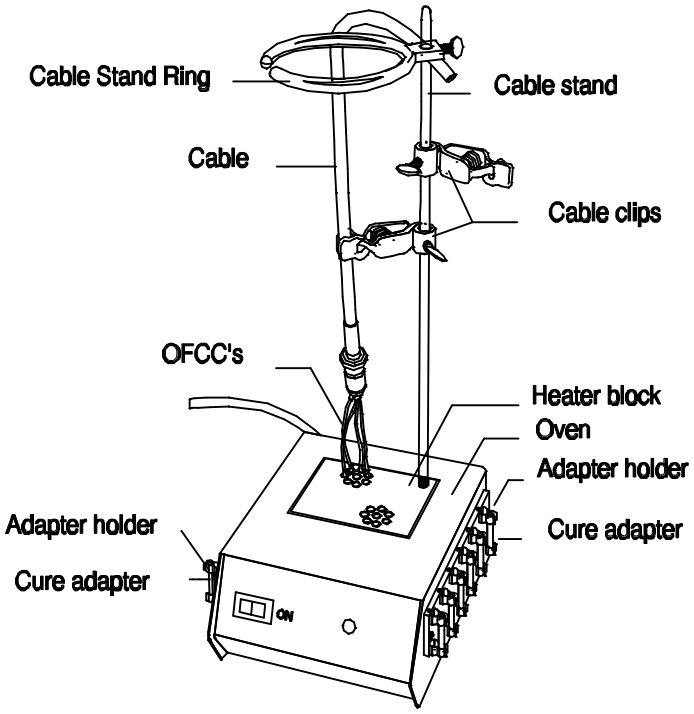


FIGURE 5A1-7. Termini in the curing oven.

Step 16 - Turn the curing oven off and remove the cure adapters and termini from the curing oven. Allow the cure adapters and termini to cool for approximately 4 minutes.

3.2.4 Polishing the fiber ends. Procedures for hand polishing are contained herein. Machine polishing may be used as an alternate method, provided the following requirements are satisfied:

a. The manufacturer's instructions will be rigidly adhered to, except that the polishing papers or disks shall be aluminum oxide 5 µm foam backed and 1 µm mylar backed, as used in hand polishing. (NOTE: Alternate polishing materials may be used if authorized approval is obtained and the polishing machine includes the appropriate stops to prevent changes to the ferrule length.)

b. The machine polished terminus shall undergo the same quality check used for the manually polished terminus as described herein.

NOTE: The procedures contained herein should produce an optical terminus with a physical contact (PC) polish.

Step 1 - **WARNING:** Wear safety glasses when scoring the fiber to avoid possible eye injury.

Remove the terminus from the cure adapter and score the fiber close to the terminus tip at the epoxy interface using one short light stroke with cleaving tool (see figure 5A1-8). (NOTE: Do not break the fibers with the cleaving tool.) Pull off each fiber with a gentle, straight pull. Deposit the waste fiber in a trash container.

NOTE: The termini not being polished should be left in the cure adapters during the polishing process to protect the fibers from breakage.

NOTE: Before inserting the terminus into the polishing tool, the terminus may be held vertically and the end of the fiber polished off by lightly running the 5 µm polishing paper over the top of the terminus tip. (This is referred to as air polishing the terminus.)

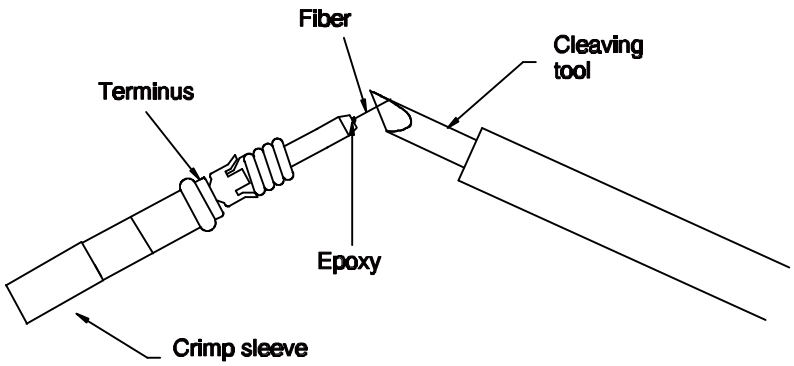


FIGURE 5A1-8. Scoring the fiber.

Step 2 - Rotate the top half of the polishing tool 90 degrees counterclockwise and separate the top from the base.

Step 3 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-9).

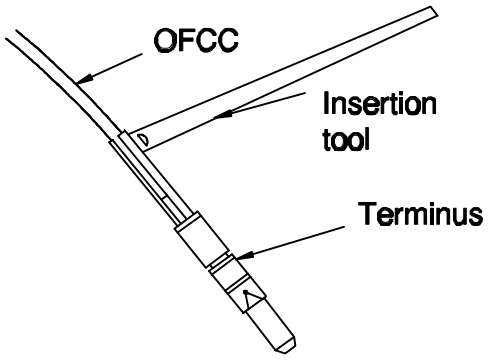


FIGURE 5A1-9. Placing the terminus in the insertion tool.

Step 4 - Insert the terminus into the center of the polishing tool top. Apply pressure with the insertion tool until the terminus snaps into place. Remove the tool by pulling straight back (see figure 5A1-10). (NOTE: Difficulty in inserting the terminus into the polishing tool may indicate epoxy on outside of the terminus which must be removed before proceeding.)

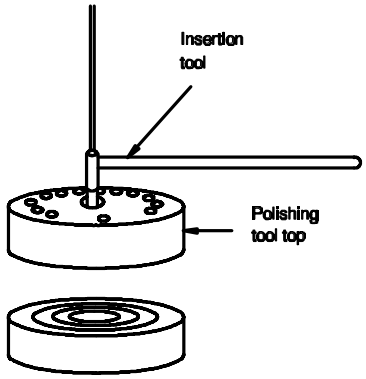


FIGURE 5A1-10. Inserting the terminus in the polishing tool.

Step 5 - Install the top half of the polishing tool on the bottom half and rotate it clockwise (90 degrees) until it locks in place.

Step 6 - Clean the glass polishing plate, the backs of the polishing papers, and the surface of the polishing tool using a wipe dampened with alcohol. Blow all of the surfaces dry with air.

Step 7 - Place the 5 µm polishing paper on the glass plate and start polishing the terminus with very light pressure (the weight of the tool) using a figure-8 motion. Do not overpolish the terminus. (NOTE: The first polish is complete when all of the epoxy is gone from the tip of the terminus.) Since the polishing time varies with the amount of epoxy present on the tip of the terminus, inspect the terminus tip frequently. Whenever the polishing tool is lifted, remove the grit from the tool and the terminus with air. When polishing is complete, clean the terminus and the polishing tool using a wipe dampened with alcohol and blow them dry with air. Perform a rough inspection of the ferrule end using the eye loop.

Step 8 - Replace the 5 µm paper with the 1 µm paper. Wet the paper and polish the terminus with very light pressure using a figure-8 motion for 10 to 20 complete motions.

Step 9 - Rotate the top of the polishing tool counterclockwise (90 degrees) and separate the top from the base. Insert the terminus removal tool into the bottom of the terminus cavity of the polishing tool top and press on the hilt of the removal tool until the tool clicks into place (see figure 5A1-11). Depress the plunger and slide the terminus out of the polishing tool. Clean the terminus and the polishing tool with a wipe dampened with alcohol and blow them dry with air.

Step 10 - Repeat steps 1 through 9 for all of the termini.

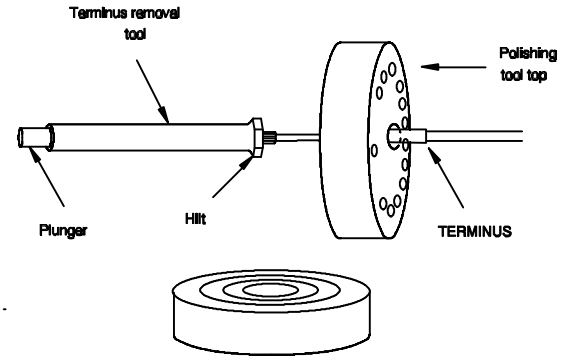


FIGURE 5A1-11. Removing the terminus from the polishing tool.

3.2.5 Quality check.

Step 1 - Examine the terminus with the optical microscope to ensure that the optical surface is smooth and free of scratches, pits, chips, and fractures. If any defects are present, repeat steps 2 through 6, 8, and 9 or reterminate the fiber (see figure 5A1-12). (NOTE: Overpolishing the fiber will increase the optical loss of the terminus. Do not polish the terminus more than necessary to pass the quality check.) A high intensity back light may be used to illuminate the fiber during the quality check.

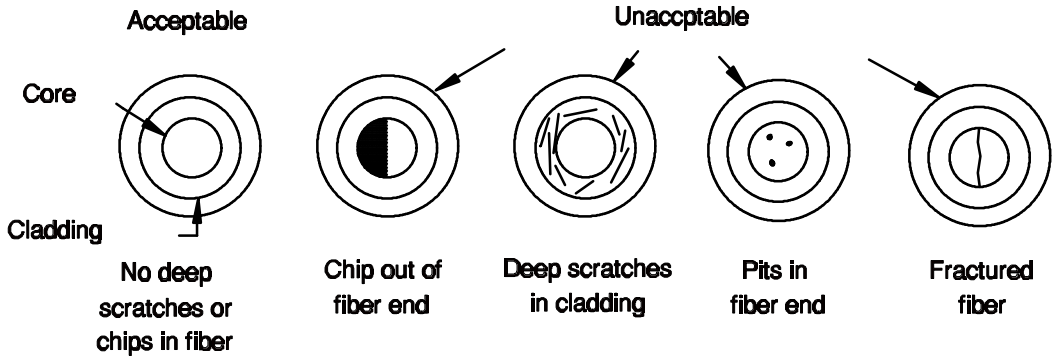


FIGURE 5A1-12. Quality check.

3.2.6 Installation of the terminus into the connector insert.

NOTE: The termini may be installed before or after the connector backshell has been assembled onto the connector shell. If the connector backshell has been assembled to the connector shell, the backshell sheath must be removed in order to install the termini.

Step 1 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-9).

Step 2 - If it has not already been done, install the insert into the connector shell. (NOTE: Make sure that the insert key is properly aligned in the connector shell keyway before installing the insert.) Place the terminus in the proper cavity in the rear of the connector insert. Apply pressure with the insertion tool until the terminus snaps into place (see figure 5A1-13). Remove the tool by pulling straight back. (NOTE: A properly inserted terminus will have some axial "play" within the insert cavity.)

NOTE: A socket terminus, unlike a pin terminus, will require installation of the alignment sleeves after seating the terminus. Proceed to step 3 below for socket termini. For pin termini repeat steps 1 and 2 for the rest of the termini.

Step 3 - Place the end of the socket terminus alignment sleeve installation and removal tool into the solid end of the alignment sleeve, depress the plunger to grasp the alignment sleeve, and press the sleeve into the socket terminus cavity in the face of the insert (see figure 5A1-14). Press until the sleeve

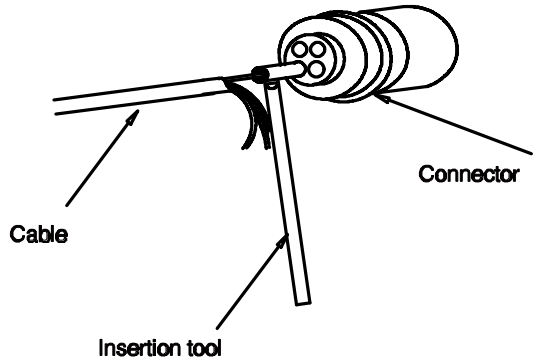


FIGURE 5A1-13. Installing the terminus in the insert.

snaps onto the groove on the ceramic terminus body.

CAUTION: Do not rotate the tool after the sleeve is installed in the insert.

Remove the tool by releasing the plunger and pulling straight back. Proceed to step 4 below.

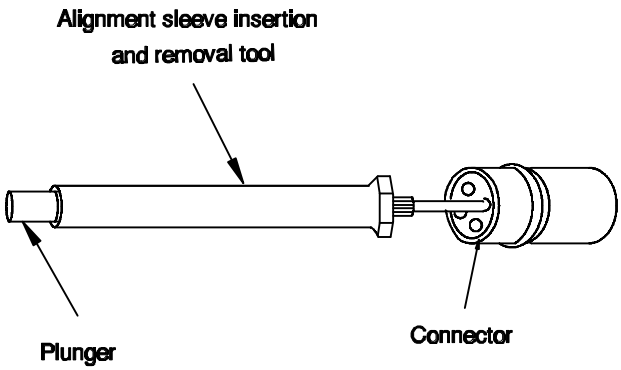


FIGURE 5A1-14. Installing the alignment sleeve.

Step 4 - Repeat steps 1 through 3 for all of the termini.

3.2.7 Removal of the termini from the connector insert.

NOTE: Perform this procedure only if the termini are to be removed from the connector.

NOTE: Proceed to step 1 below for socket termini. Proceed to step 2 below for pin termini.

Step 1 - **CAUTION:** Do not rotate the tool while the sleeve is in the insert.

Remove the alignment sleeves from the socket termini using the terminus alignment sleeve installation and removal tool by inserting the tool end into the alignment sleeve and depressing the plunger so that the tool grasps the sleeve lip. Pull the sleeve straight back. Proceed to step 2.

Step 2 - Insert the terminus removal tool into the terminus cavity from the front of the insert and press on the hilt of the tool until it snaps into place (see figure 5A1-15). Depress the plunger to slide the terminus out the rear of the insert.

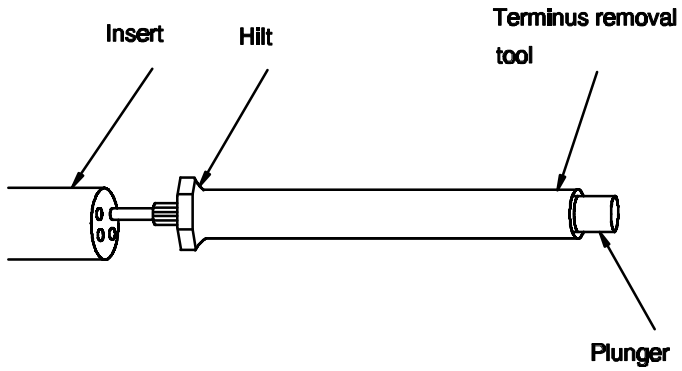


FIGURE 5A1-15. Removing the terminus from the insert.

3.2.8 Assembly of backshell.

NOTE: If the termini have been installed in the connector insert previously, take care to not pinch or twist the OFCCs during this procedure.

Step 1 - Slide the backshell body forward and screw it onto the connector shell until tight. (NOTE: Loctite or a similar material may be used to secure the backshell body to the connector shell. If Loctite or a similar material is used, use it sparingly.)

Step 2 - Remove the tape securing the kevlar strength members and slide the ferrule (kevlar grip) up to rear of backshell capturing the kevlar between the backshell and kevlar grip. Comb the kevlar over kevlar grip and retape the kevlar to the cable.

Step 3 - Slide the spacer over the kevlar up to the rear of the kevlar grip.

Step 4 - Remove the tape and trim the kevlar approximately 6 mm (0.25 in) behind the spacer using the kevlar shears.

Step 5 - Apply O-ring lube to the O-ring and slide the O-ring up behind the spacer, keeping the kevlar strands between the O-ring and the spacer.

Step 6 - Slide the backnut forward over the O-ring, spacer, and kevlar grip and screw it tightly to the backshell body (NOTE: Use an adjustable wrench on the backshell body flats and the backshell grip on the backnut. Use care to not nick or scratch the backshell coating during assembly.)

Step 7 - Apply O-ring lube to the O-rings on the sheath and slide the sheath forward and screw it onto the backshell body until it is tight.

Step 8 - Install the plastic protective cap over the front of the connector.

3.3 Procedure II. Method 5A1-2 Installation of connectors with non removable backshells. This method shall be used to install connectors with part numbers M28876/2, M28876/3, M28876/4, M28876/7, M28876/8, M28876/9, M28876/12, M28876/13, and M28876/14 onto fiber optic cables.

3.3.1 The equipment and materials in table 5A1-III shall be used to perform this procedure:

TABLE 5A1-III. Equipment and materials.

Description	Quantity
Ruler	1
Wipes (NAVSEA DWG 6872813-22 or equal)	As required
Alcohol bottle with alcohol/2-propanol or equal (sealable type)	1
Canned air or compressed air	As required
Cable jacket stripping tool (NAVSEA DWG 6872813-8 or equal)	1
Masking tape	As required
"O"-ring lubricant (Bray Cote 609 or equal)	As required
O-ring tools (NAVSEA DWG 6872813-5 or equal)	As required
Spanner wrench (NAVSEA DWG 6872813-5 or equal)	1
Torque wrench adapters (NAVSEA DWG 6872813-5 or equal)	As required
Hex adapter (NAVSEA DWG 6872813-29)	1
Torque wrench (NAVSEA DWG 6872813-1 or equal)	1
Heat gun	1
Kevlar shears (NAVSEA DWG 6872813-16 or equal)	1
OFCC strip tool (NAVSEA DWG 6872813-10 or equal)	1
Safety glasses	1
Buffer strip tool (NAVSEA DWG 6872813-9 or equal)	1
Cleaning wire (NAVSEA DWG 6872813-32 or equal)	As required
Epoxy (MIL-A-24792)	As required
Syringe with dispensing needles (NAVSEA DWG 6872813-27 or equal)	As required
Crimp tool (NAVSEA DWG 6872813-17 or equal)	1
Razor blade	1
Cure adapters (NAVSEA DWG 6872813-19 or equal)	As required
Curing oven (NAVSEA DWG 6872813-19 or equal)	1
Cable stand (NAVSEA DWG 6872813-19 or equal)	1
Cable stand ring (NAVSEA DWG 6872813-19 or equal)	1
Cable clip (NAVSEA DWG 6872813-19 or equal)	1
Cleaver (NAVSEA DWG 6872813-7 or equal)	1
Polishing paper (5 µm aluminum oxide, foam backed) (NAVSEA DWG 6872813-24 or equal)	As required

TABLE 5A1-III. Equipment and materials - continued.

Description	Quantity
Polishing tool ceramic termini (NAVSEA DWG 6872813-18 or equal)	1
Terminus insertion tool (NAVSEA DWG 6872813-2 or equal)	1
Terminus insertion tool 90° (NAVSEA DWG 6872813-15 or equal)	1
Glass polishing plate (NAVSEA DWG 6872813-3 or equal)	1
7X eye loupe	1
Polishing paper (1 µm aluminum oxide, mylar backed) (NAVSEA DWG 6872813-23 or equal)	As required
Water bottle (sealable type)	1
Terminus removal tool (NAVSEA DWG 6872813-6 or equal)	1
Optical microscope 400X (NAVSEA DWG 6872813-28 or equal)	1
Alignment sleeve insertion and removal tool (ceramic termini)(NAVSEA DWG 6872813-4 or equal)	1
Backshell grip	1
Adjustable wrench	1
Protective caps (plastic)	As required

CAUTION: Throughout the termination process, cleanliness is critical to obtaining a high optical quality connector. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the connector parts.

NOTE: Verify that the epoxy shelf life has not expired. Do not use epoxy with an expiration date that has passed.

3.3.2 Cable preparation.

NOTE: The connector is received assembled with O-rings installed, with the exception of the kevlar retaining O-ring which is taped to the backshell exterior.

Step 1 - Ensure cable is the correct type as specified on the applicable cable diagram.

Step 2 - Measure the cable to the required length. Then add sufficient slack to allow for at least two reterminations [178 mm (7 inches) of slack should be sufficient for one retermination].

Step 3 - Clean the outer cable jacket that will be in contact with the connector and backshell with a wipe dampened with alcohol and blow it dry with air.

NOTE: Keep the cable and connector parts free from oil, dirt, and grease throughout the installation procedure. If cleaning is necessary, use a wipe dampened with alcohol and blow the parts dry with air.

3.3.3 Securing the strain relief.

Step 1 - Slide the strain relief onto cable in the order indicated (see figure 5A1-16):

a. Compression nut with boot

b. Shrink tubing

c. Strain relief housing

d. Compression ring

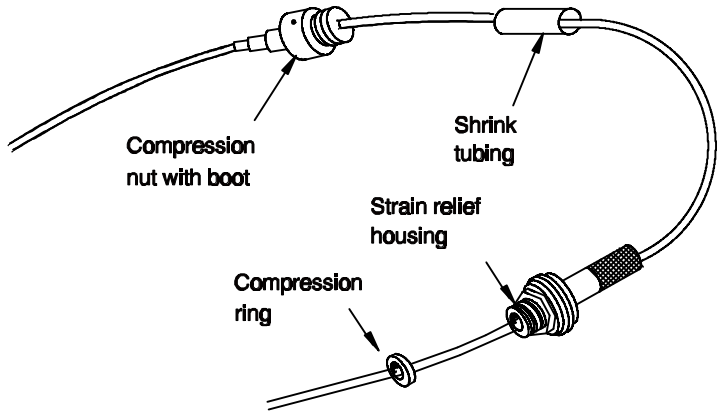


FIGURE 5A1-16. Strain relief parts on the cable.

Step 2 - Mark the cable approximately 165 mm (6.5 in) from the end and strip back the outer cable jacket using the cable stripper. Fold back the kevlar strength members and temporarily tape them to the cable outer jacket.

CAUTION: Do not cut or nick the OFCC jackets.

Cut off the exposed central member and any fillers using the kevlar shears.

Step 3 - Remove any water blocking material and clean the OFCC's using a wipe dampened with alcohol and blow them dry with air.

Step 4 - Remove the tape from the kevlar strength members and fold them forward. Slide the compression ring to the end of the cable jacket. (NOTE: The grooved side of ring should face the strain relief housing.) Fold the kevlar strength members back over the compression ring and the cable in the direction of the strain relief housing.

Step 5 - Remove the O-ring (taped to the backshell exterior) and apply O-ring lubricant. Place the O-ring on the O-ring installation tool by forcing the O-ring up the cone to the larger end of the tool.

Step 6 - Slide the O-ring tool up the OFCCs (larger opening first) over the compression ring (and kevlar strength members) and force the O-ring over the compression ring onto the kevlar (see figure 5A1-17). Remove the O-ring tool.

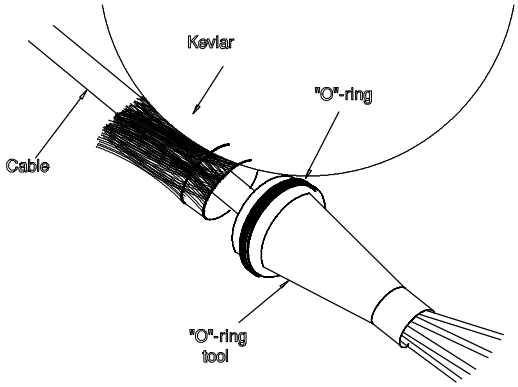


FIGURE 5A1-17. Installing the O-ring.

Step 7 - Fold the kevlar strength members forward over the O-ring and the compression ring. Tape the kevlar members to the OFCCs to ease the installation of the kevlar compression nut.

Step 8 - Slide the strain relief housing up the cable to the compression ring. Gently feed the OFCCs and kevlar through the kevlar compression nut and slide the nut up to the strain relief housing. Thread the compression nut onto the strain relief housing while pulling the kevlar taut.

Step 9 - Tighten the kevlar compression nut to 2.75 N·m (25 inch-pounds) using the wrench, the torque adapter, the hex adapter, and the torque tool (see figure 5A1-18). Remove the wrench and the other tools.

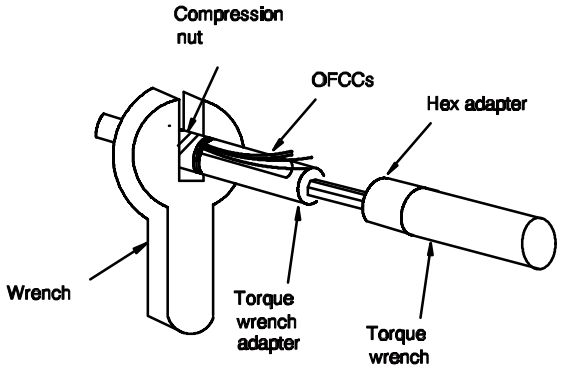


FIGURE 5A1-18. Tightening the kevlar compression nut.

Step 10 - Remove the tape and trim the kevlar down to the face of the kevlar compression nut using the kevlar shears.

NOTE: The following step may be performed at this time or later in the connector assembly process after completion of the quality check (see 3.3.7).

Step 11 - Slide the shrink tubing over the knurled end of the strain relief housing up to the shoulder.

CAUTION: Do not overheat the cable. Prolonged exposure of the jacket to temperatures above 160°C (320°F) may damage the cable jacket. Discontinue heating of the tubing and allow the cable jacket to cool before reheating if the cable jacket shows any signs of bubbling or necking.

Starting at the strain relief housing, hold the heat gun approximately 102 mm (4 inches) from the tubing and apply heat until the tubing shrinks to a tight fit.

3.3.4 Fiber preparation.

Step 1 - Feed each OFCC into a crimp sleeve and slide the sleeve back from the end of the OFCC. (NOTE: Only use crimp sleeves intended for termini. Do not use crimp sleeves intended for other types of connectors. The standard crimp sleeve for the terminus may be oriented in either direction.)

Step 2 - Trim the OFCC's to dimension A in table 5A1-IV using the kevlar shears (see figure 5A1-19).

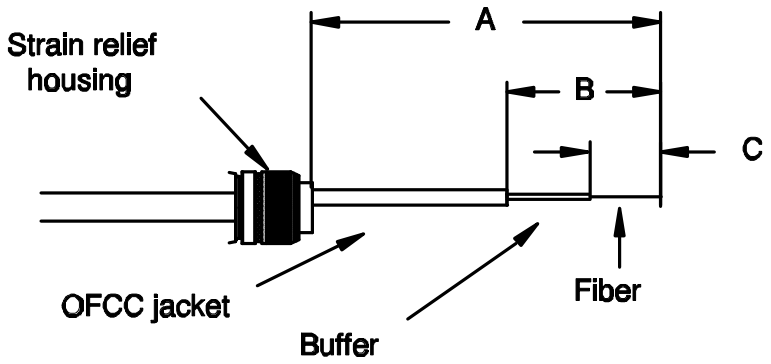


FIGURE 5A1-19. Cable stripping dimensions.

TABLE 5A1-IV. Cable stripping dimensions.

Connector shell size	Backshell configuration	Dimensions mm (in)		
		A	B	C
13	Straight	110 (4.3)	30 (1.2)	19 (0.7)
	45°	110 (4.3)	30 (1.2)	19 (0.75)
	90°	110 (4.3)	30 (1.2)	19 (0.75)
15	Straight	110 (4.3)	30 (1.2)	19 (0.75)
	45°	120 (4.7)	30 (1.2)	19 (0.75)
	90°	120 (4.7)	30 (1.2)	19 (0.75)

Step 3 - Remove the OFCC jackets back to dimension B in table 5A1-IV using the OFCC stripper and trim the OFCC kevlar so that approximately 3 mm (0.12 in) extends past the OFCC jacket.

Step 4 - **WARNING:** Wear safety glasses when removing the fiber buffer and coating to avoid possible eye injury.

Remove the fiber buffers and coatings back to dimension C in table 5A1-IV using the buffer stripper. Remove the buffer and coating in small sections (approximately 6 mm (0.25 in) at a time). (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

Step 5 - **CAUTION:** The uncoated fiber is in its most vulnerable state. Take extreme care not to damage the fiber. Breakage of any one fiber from this point until the connector is completely assembled will require repetition of this and the following steps in order to maintain approximately equal length of all the fibers in the cable.

Remove any residual coating material from the bare fibers with a wipe dampened with alcohol. Wipe only once from the end of the buffer towards the end of the fiber. (NOTE: Do not repeatedly wipe the bare fiber as this will weaken the fiber.)

3.3.5 Installation of termini onto fibers.

NOTE: This procedure describes the process for installing ceramic termini onto either multimode or single-mode fibers. The termini use epoxy to secure the fiber and a crimp sleeve to capture the kevlar strength members of the OFCC's.

Step 1 - Turn on the curing oven so that it attains the proper temperature before the termini are placed within it (approximately 20 minutes).

Step 2 - Inspect the terminus and verify that the ferrule hole is free and clean of dirt. This can be accomplished by holding the front of the terminus up to a light and verifying that the light is visible from the rear of the terminus. If light cannot be seen through the terminus, push music wire through the terminus hole to clear it. Then blow dry air through the hole to remove any debris.

Step 3 - Remove the divider from a 2-part epoxy package and mix the two parts together until the epoxy is a smooth uniform color (see figure 5A1-20). The epoxy can be mixed by either repeatedly rolling the divider over the package or gently sliding the divider over the package.

NOTE: Alternatively, the epoxy may be mixed by massaging the epoxy package by hand.

CAUTION: Do not introduce large air bubbles into the epoxy during the mixing process. Large air bubbles in the epoxy can lead to connector failure during temperature extremes.

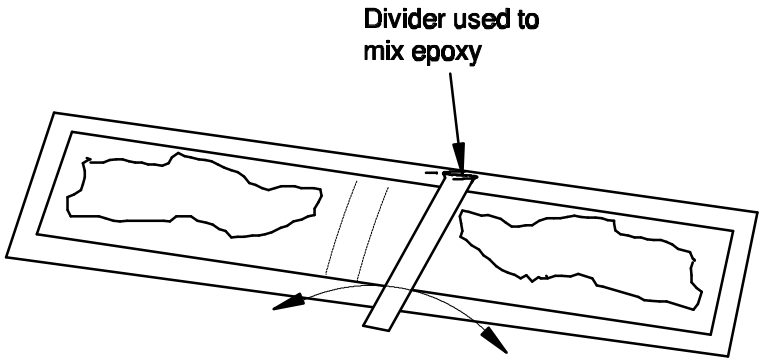


FIGURE 5A1-20. Mixing the epoxy.

Step 4 - Install the syringe tip on the syringe, remove the plunger, and squeeze the epoxy into the syringe. Replace the plunger.

Step 5 - **WARNING:** Wear safety glasses while dispensing the epoxy to avoid possible eye injury.

Remove air pockets in the syringe by holding the tip of the syringe upward and dispensing epoxy onto a wipe until it runs free and clear.

Step 6 - Slide the terminus, rear first, onto the syringe tip (see figure 5A1-21). Keeping the syring vertical, depress the plunger and slowly inject epoxy into the terminus until it escapes out of the ferrule, forming a very small bead. (NOTE: Do not overfill. Be extremely careful not to get epoxy on the pin spring or other terminus moving parts.)

Step 7 - Withdraw the syringe from the terminus. Maintain some pressure on the plunger as the syringe is withdrawn so that the terminus is completely filled with epoxy. Using a wipe dampened with alcohol, wipe away any epoxy on the outer diameter of ferrule without disturbing the epoxy bead.

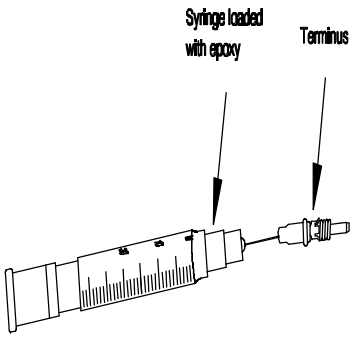


FIGURE 5A1-22. Injecting epoxy into the terminus.

NOTE: Alternatively, the terminus may be completely filled by maintaining a light pressure on the syringe plunger and allowing the epoxy to push the terminus off of the syringe tip.

Step 8 - Feather the kevlar evenly around the fiber and insert the fiber into the rear of the terminus (see figure 5A1-22). Gently work the fiber through the terminus until the buffer seats against the rear of the ferrule. The OFCC jacket should come up to the rear of the terminus and the kevlar should surround the rear of the terminus. Once inserted, do not allow the fiber to slip back.

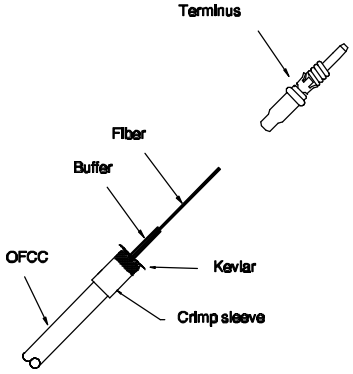


FIGURE 5A1-22. Inserting the fiber into the terminus.

Step 9 - Slide the crimp sleeve over the kevlar and crimp it to the rear of the terminus using the crimp tool. (NOTE: A small amount of epoxy may be added on the kevlar near the rear of the terminus before the crimp sleeve is installed. However, no epoxy should be visible once the crimp sleeve is installed.)

Step 10 - Verify that the kevlar does not protrude excessively from under the crimp sleeve. Excessive kevlar protrusion will cause the terminus to not seat properly in the finished connector. If excessive kevlar protrudes from under the crimp sleeve, trim it back using a razor blade.

Step 11 - Verify that there is a small amount of epoxy around the fiber where it protrudes from the ferrule. If it is found that there is no small bead of epoxy on the terminus tip, carefully add a small amount of epoxy around the fiber. (NOTE: There should only be a small amount of epoxy around the fiber to support it later during the polishing process. If too much epoxy is around the fiber during the curing process it may cause the fiber to crack.)

Step 12 - Using a wipe dampened with alcohol, carefully wipe away any excess epoxy on the fiber that is more than 2 mm (0.08 in) from the ferrule tip surface.

Step 13 - Insert the terminus into the cure adapter until it snaps into place (see figure 5A1-23.)
Step 14 - Repeat steps 1 through 12 for each fiber to be terminated.

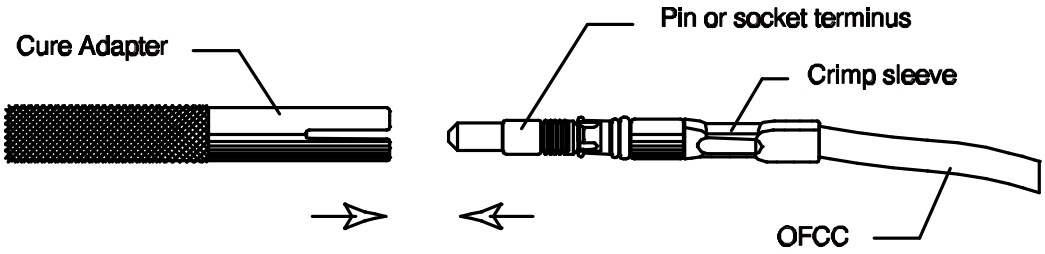


FIGURE 5A1-23. Inserting a terminus in a cure adapter.

Step 15 - Place the cure adapters in the curing oven, and position the cable vertically over the oven using the cable stand, cable stand ring and cable clip (see figure 5A1-24). Cure the epoxy for a minimum of 10 minutes (maximum of 30 minutes) at 120°C (248°F). (NOTE: When the cable is positioned above the terminus, make sure that no bends are placed in the OFCCs. Each OFCC should enter the terminus parallel to the terminus.)

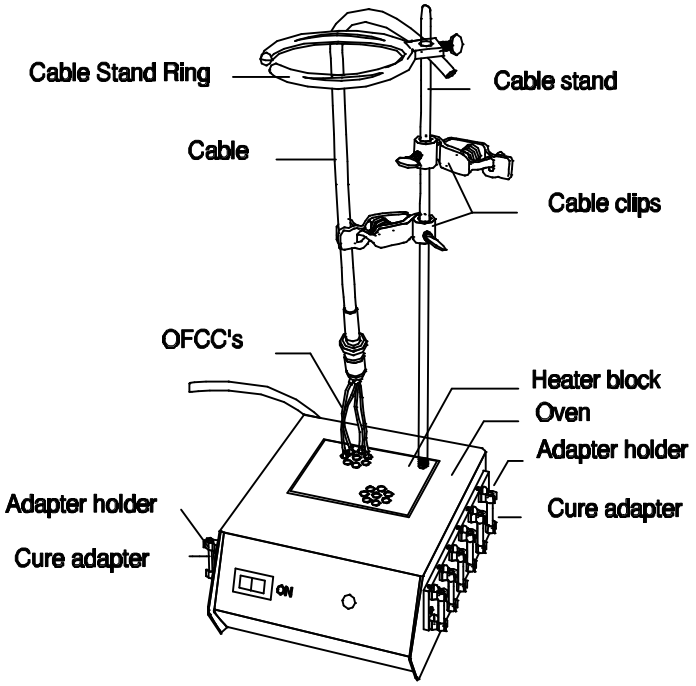


FIGURE 5A1-25. Termini in the curing oven.

Step 16 - Turn the curing oven off and remove the cure adapters and termini from the curing oven. Allow the cure adapters and termini to cool for approximately 4 minutes.

3.3.6 Polishing the fiber ends. Procedures for hand polishing are contained herein. Machine polishing may be used as an alternate method, provided the following requirements are satisfied:

a. The manufacturer's instructions will be rigidly adhered to, except that the polishing papers or disks shall be aluminum oxide 5 µm foam backed and 1 µm mylar backed, as used in hand polishing. (NOTE: Alternate polishing materials may be used if authorized approval is obtained and the polishing machine includes the appropriate stops to prevent changes to the ferrule length.)

b. The machine polished terminus shall undergo the same quality check used for the manually polished terminus as described herein.

NOTE: The procedures contained herein should produce an optical terminus with a physical contact (PC) polish.

Step 1 - **WARNING:** Wear safety glasses when scoring the fiber to avoid possible eye injury.

Remove the terminus from the cure adapter and score the fiber close to the terminus tip at the epoxy interface using one short light stroke with cleaving tool (see figure 5A1-25). (NOTE: Do not break the fibers with the cleaving tool.) Pull off each fiber with a gentle, straight pull. Deposit the waste fiber in a trash container.

NOTE: The termini not being polished should be left in the cure adapters during the polishing process to protect the fibers from breakage.

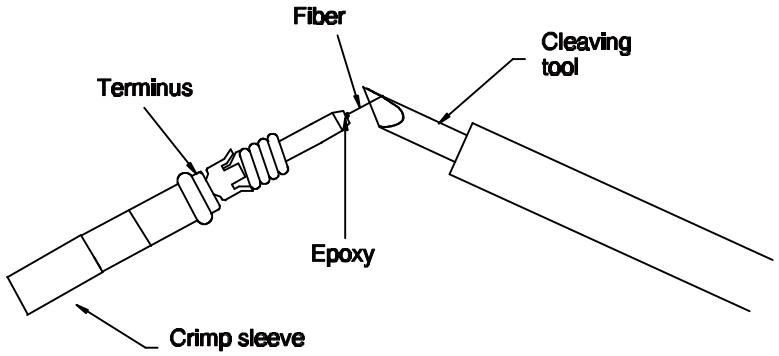


FIGURE 5A1-25. Scoring the fiber.

NOTE: Before inserting the terminus into the polishing tool, the terminus may be held vertically and the end of the fiber polished off by lightly running the 5 µm polishing paper over the top of the terminus tip. (This is referred to as air polishing the terminus.)

Step 2 - Rotate the top half of the polishing tool 90 degrees counterclockwise and separate the top from the base.

Step 3 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-26).

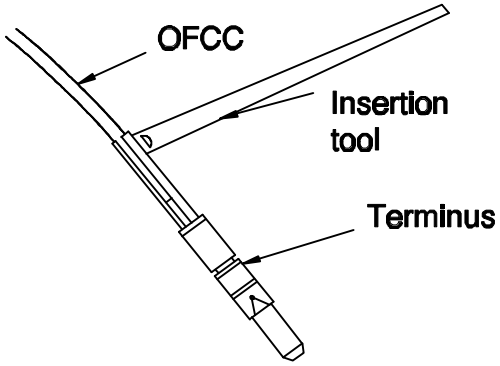


FIGURE 5A1-26. Placing the terminus in the insertion tool.

Step 4 - Insert the terminus into the center of the polishing tool top. Apply pressure with the insertion tool until the terminus snaps into place. Remove the tool by pulling straight back (see figure 5A1-27). (NOTE: Difficulty in inserting the terminus into the polishing tool may indicate epoxy on outside of the terminus which must be removed before proceeding.)

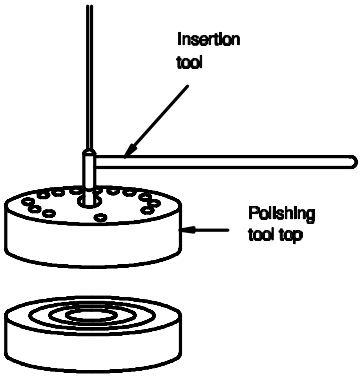


FIGURE 5A1-27. Inserting the terminus in the polishing tool.

Step 5 - Install the top half of the polishing tool on the bottom half and rotate it clockwise (90 degrees) until it locks in place.

Step 6 - Clean the glass polishing plate, the backs of the polishing papers, and the surface of the polishing tool using a wipe dampened with alcohol. Blow all of the surfaces dry with air.

Step 7 - Place the 5 µm polishing paper on the glass plate and start polishing the terminus with very light pressure (the weight of the tool) using a figure-8 motion. Do not overpolish the terminus. (NOTE: The first polish is complete when all of the epoxy is gone from the tip of the terminus.) Since the polishing time varies with the amount of epoxy present on the tip of the terminus, inspect the terminus tip frequently. Whenever the polishing tool is lifted, remove the grit from the tool and the terminus with air. When polishing is complete, clean the terminus and the polishing tool using a wipe dampened with alcohol and blow them dry with air. Perform a rough inspection of the ferrule end using the eye loop.

Step 8 - Replace the 5 µm paper with the 1 µm paper. Wet the paper and polish the terminus with very light pressure using a figure-8 motion for 10 to 10 complete motions.

Step 9 - Rotate the top of the polishing tool counterclockwise (90 degrees) and separate the top from the base. Insert the terminus removal tool into the bottom of the terminus cavity of the polishing tool top and press on the hilt of the removal tool until the tool clicks into place (see figure 5A1-28). Depress the plunger and slide the terminus out of the polishing tool. Clean the terminus and the polishing tool with a wipe dampened with alcohol and blow them dry with air.

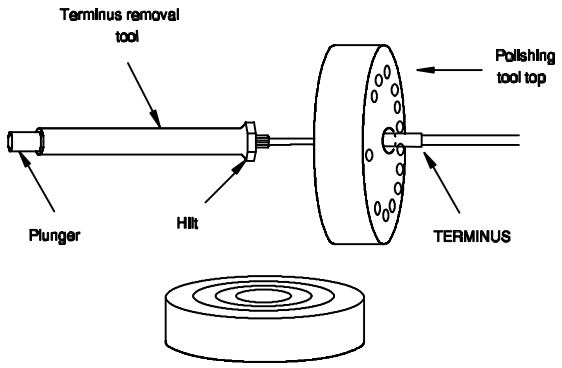


FIGURE 5A1-28. Removing the terminus from the polishing tool.

Step 10 - Repeat steps 1 through 9 for all of the termini.

3.3.7 Quality check.

Step 1 - Examine the terminus with the optical microscope to ensure that the optical surface is smooth and free of scratches, pits, chips, and fractures. If any defects are present, repeat steps 2 through 6, 8, and 9 or reterminate the fiber (see figure 5A1-29). (NOTE: Overpolishing the fiber will increase the optical loss of the terminus. Do not polish the terminus more than necessary to pass the quality check.) A high intensity back light may be used to illuminate the fiber during the quality check.

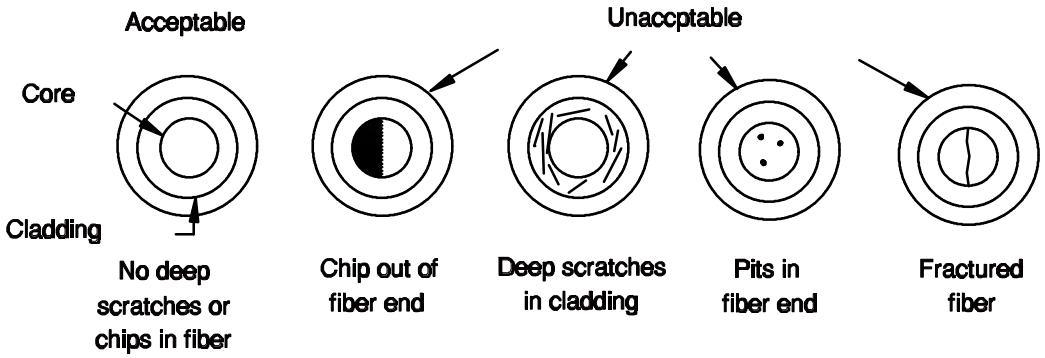


FIGURE 5A1-29. Quality check.

3.3.8 Installation of the terminus into the connector insert.

NOTE: Proceed to step 1a for straight (in-line) backshell connectors. Proceed to step 1b for 45° or 90° (angle) backshell connectors.

Step 1a - Fit the spacing shafts of the insert into the notches in the face of the strain relief until they snap into place (see figure 5A1-30). Proceed to step 2.

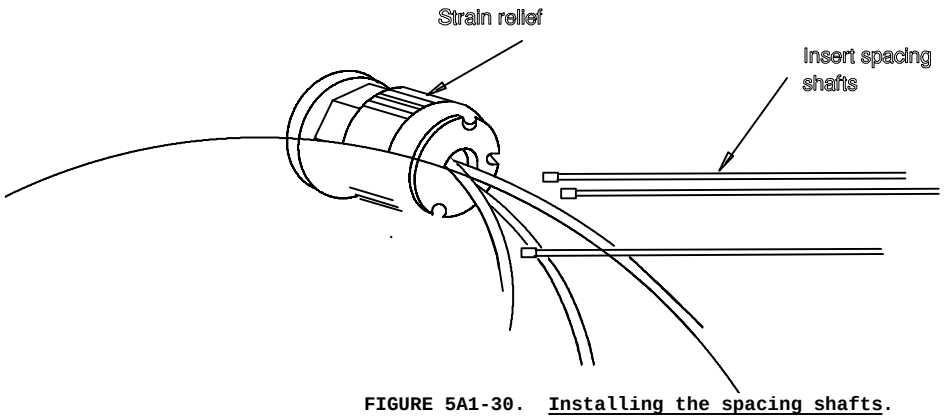


FIGURE 5A1-30. Installing the spacing shafts.

Step 1b - Slide the strain relief/cable assembly into the backshell. When the strain relief assembly stops, rotate the backshell until the strain relief assembly aligns with the backshell. When they are aligned, fully seat the strain relief assembly by sliding it the rest of the way into the backshell. (NOTE: A properly seated strain relief assembly should be recessed approximately 10 mm (.4 in) from the rear of the backshell.) Proceed to step 2.

Step 2 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-26).

Step 3 - Place the terminus in the proper cavity in the rear of the connector insert. Apply pressure with the insertion tool until the terminus snaps into place (see figure 5A1-31). Remove the tool by pulling straight back. (NOTE: A properly inserted terminus will have some axial "play" within the insert cavity.)

NOTE: A socket terminus, unlike a pin terminus, will require installation of the alignment sleeves after seating the terminus. Proceed to step 4 below for socket termini. For pin termini repeat steps 2 and 3 for the rest of the termini.

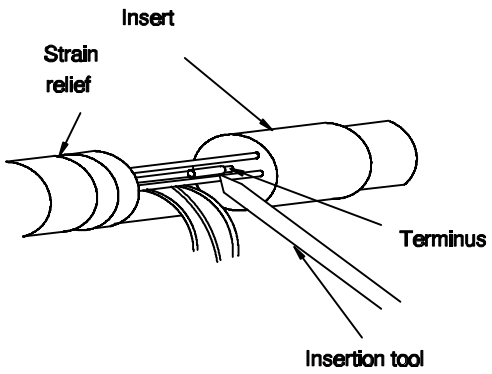


FIGURE 5A1-31. Installing the terminus in the insert.

Step 4 - Place the end of the socket terminus alignment sleeve installation and removal tool into the solid end of the alignment sleeve, depress the plunger to grasp the alignment sleeve, and press the sleeve into the socket terminus cavity in the face of the insert (see figure 5A1-32). Press until the sleeve snaps onto the groove on the ceramic terminus body.

CAUTION: Do not rotate the tool after the sleeve is installed in the insert.

Remove the tool by releasing the plunger and pulling straight back. Proceed to step 5 below.

Step 5 - Repeat steps 1 through 4 for all of the termini.

3.3.9 Removal of the termini from the connector insert.

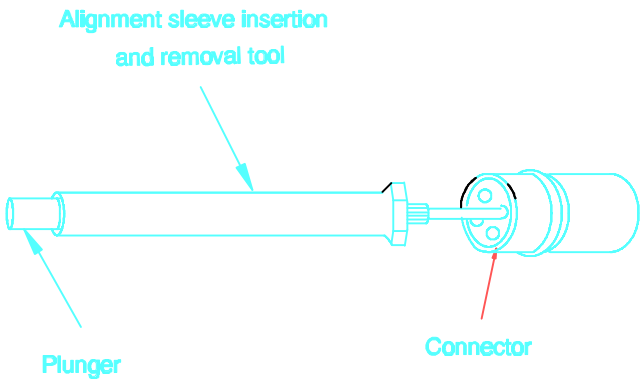


FIGURE 5A1-32. Installing the alignment sleeve.

NOTE: Perform this procedure only if the termini are to be removed from the connector.

NOTE: Proceed to step 1 below for socket termini. Proceed to step 2 below for pin termini.

Step 1 - **CAUTION:** Do not rotate the tool while the sleeve is in the insert.

Remove the alignment sleeves from the socket termini using the terminus alignment sleeve installation and removal tool by inserting the tool end into the alignment sleeve and depressing the plunger so that the tool grasps the sleeve lip. Pull the sleeve straight back. Proceed to step 2.

Step 2 - Insert the terminus removal tool into the terminus cavity from the front of the insert and press on the hilt of the tool until it snaps into place (see figure 5A1-33). Depress the plunger to slide the terminus out the rear of the insert.

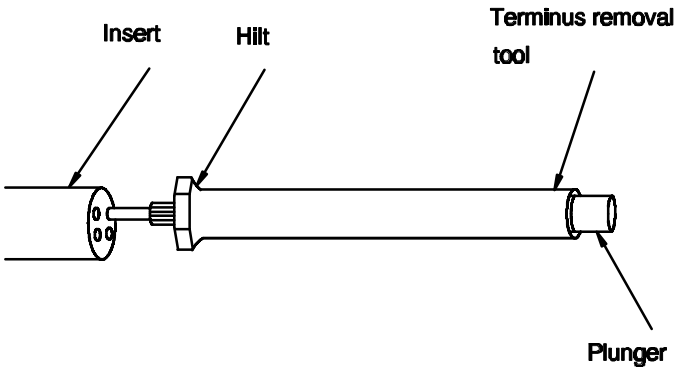


FIGURE 5A1-33. Removing the terminus from the insert.

3.3.10 Assembly of the backshell.

3.3.10.1 Straight backshells.

Step 1 - Slide the insert/strain relief/cable assembly into the backshell (see figure 5A1-34). When the insert stops, rotate the backshell until the key on the insert aligns with the keyway in the backshell. When they are aligned, fully seat the insert by sliding the insert/strain relief/cable assembly the rest of the way into the backshell. (NOTE: A properly seated insert should cause the strain relief assembly to be recessed approximately 10 mm (.4 in) from the rear of the backshell.)

Step 2 - **CAUTION**: Make sure that the insert key is properly aligned in the connector shell keyway and the insert fully seated in the connector shell before threading the compression nut into the backshell. Failure to properly seat the insert in the connector shell will cause breakage of the spacer shafts when the compression nut is threaded into the connector shell.

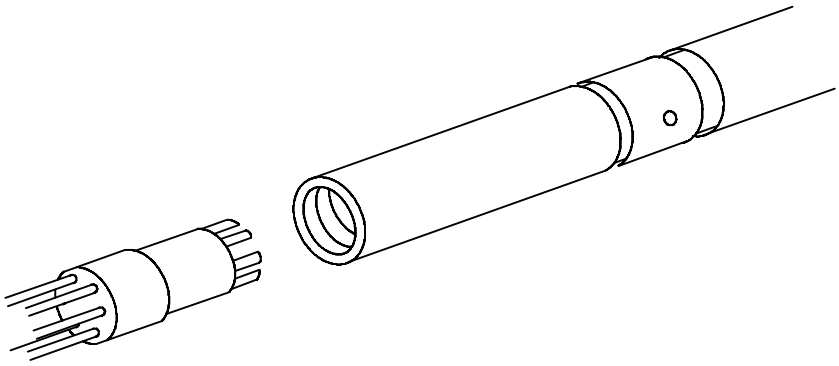


FIGURE 5A1-34. Assembling the backshell.

Slide the compression nut up to the backshell, thread it into the backshell and tighten it using the spanner wrench, torque wrench and backshell grip to 6.6 Nm (60 inch-pounds). Use care to not nick or scratch the backshell coating during assembly.

Step 3 - Install the plastic protective cap over the front of the connector.

3.3.10.2 45° and 90° (angle) backshells.

Step 1 - **CAUTION**: Make sure that the OFCC's will not be pinched between the two backshell halves before assembling the backshell halves.

Assemble the two backshell halves together using a screwdriver.

Step 2 - Slide the compression nut up to the backshell, thread it into the backshell and tighten it using the spanner wrench, torque wrench and backshell grip to 6.6 Nm (60 inch-pounds). Use care to not nick or scratch the backshell coating during assembly.

Step 3 - Install the plastic protective cap over the front of the connector.

3.4 Procedure III. Method 5A1-3 Installation of connectors with insert retention nuts. This method shall be used to assemble connectors with part numbers M28876/1 and M28876/11 configured with insert retention nuts onto OFCCs.

NOTE: This procedure is applicable in the installation of connector receptacles into equipment where the termination is accomplished on OFCCs. This procedure is not appropriate for the installation of plugs or receptacles onto multifiber cables.

3.4.1 Equipment and materials. The equipment and materials in table 5A1-V shall be used to perform this procedure:

TABLE 5A1-V. Equipment and materials.

Description	Quantity
Ruler	1
Wipes (NAVSEA DWG 6872813-22 or equal)	As required
Alcohol bottle with alcohol/2-propanol or equal (sealable type)	1
Canned air or compressed air	As required
OFCC strip tool (NAVSEA DWG 6872813-10 or equal)	1
Kevlar shears (NAVSEA DWG 6872813-16 or equal)	1
Safety glasses	1
Buffer strip tool (NAVSEA DWG 6872813-9 or equal)	1
Cleaning wire (NAVSEA DWG 6872813-32 or equal)	As required
Epoxy (MIL-A-24792)	As required
Syringe with dispensing needles (NAVSEA DWG 6872813-27 or equal)	As required
Crimp tool (NAVSEA DWG 6872813-17 or equal)	1
Razor blade	1
Cure adapters (NAVSEA DWG 6872813-19 or equal)	As required
Curing oven (NAVSEA DWG 6872813-19 or equal)	1
Cable stand (NAVSEA DWG 6872813-19 or equal)	1
Cable stand ring (NAVSEA DWG 6872813-19 or equal)	1
Cable clip (NAVSEA DWG 6872813-19 or equal)	1
Cleaver (NAVSEA DWG 6872813-7 or equal)	1
Polishing paper (5 µm aluminum oxide, foam backed) (NAVSEA DWG 6872813-24 or equal)	As required
Polishing tool ceramic termini (NAVSEA DWG 6872813-18 or equal)	1
Terminus insertion tool (NAVSEA DWG 6872813-2 or equal)	1
Terminus insertion tool 90° (NAVSEA DWG 6872813-15 or equal)	1
Glass polishing plate (NAVSEA DWG 6872813-3 or equal)	1
7X eye loupe	1
Polishing paper (1 µm aluminum oxide, mylar backed) (NAVSEA DWG 6872813-23 or equal)	As required

TABLE 5A1-V. Equipment and materials - continued.

Description	Quantity
Water bottle (sealable type)	1
Terminus removal tool (NAVSEA DWG 6872813-6 or equal)	1
Optical microscope 400X (NAVSEA DWG 6872813-28 or equal)	1
Alignment sleeve insertion and removal tool (ceramic termini)(NAVSEA DWG 6872813-4 or equal)	1
Protective caps (plastic)	As required

CAUTION: Throughout the termination process, cleanliness is critical to obtaining a high optical quality connector. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the connector parts.

NOTE: Verify that the epoxy shelf life has not expired. Do not use epoxy with an expiration date that has passed.

3.4.2 Cable and fiber preparation.

Step 1 - Ensure the OFCCs are the correct type as specified on the applicable cable diagram.

Step 2 - Measure the OFCCs to the required length. Then add sufficient slack to allow for at least two reterminations [40 mm (1.60 inches) of slack should be sufficient for one retermination].

Step 3 - Clean the OFCC outer jackets with a wipe dampened with alcohol and blow them dry with air.

NOTE: Keep the OFCCs and connector parts free from oil, dirt and grease throughout the installation procedure. If cleaning is necessary, use a wipe dampened with alcohol and blow the part dry with air.

Step 4 - Feed each OFCC into a crimp sleeve and slide the sleeve back from the end of the OFCC. (NOTE: Only use crimp sleeves intended for termini. Do not use crimp sleeves intended for other types of connectors.)

Step 5 - Remove the OFCC jackets back 30 mm (1.20 in) from the end of the fiber using the OFCC stripper and trim the OFCC kevlar using the kevlar shears so that approximately 3 mm (0.12 in) extends past the OFCC jacket.

Step 6 - **WARNING:** Wear safety glasses when removing the fiber buffer and coating to avoid possible eye injury.

Remove the fiber buffers and coatings back 19 mm (0.75 in) from the end of the fiber using the buffer stripper. Remove the buffer and coating in small sections (approximately 6 mm (0.25 in) at a time.) (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

Step 7 - **CAUTION:** The uncoated fiber is in its most vulnerable state. Take extreme care not to damage the fiber.

Remove any residual coating material from the bare fibers with a wipe dampened with alcohol. Wipe only once from the end of the buffer towards the end of the fiber. (NOTE: Do not repeatedly wipe the bare fiber as this will weaken the fiber.)

3.4.3 Installation of the termini onto the fibers.

NOTE: This procedure describes the process for installing ceramic termini onto either multimode or single-mode fibers. The termini use epoxy to secure the fiber and a crimp sleeve to capture the kevlar strength members of the OFCC's.

Step 1 - Turn on the curing oven so that it attains the proper temperature before the termini are placed within it (approximately 20 minutes).

Step 2 - Inspect the terminus and verify that the ferrule hole is free and clean of dirt. This can be accomplished by holding the front of the terminus up to a light and verifying that the light is visible from the rear of the terminus. If light cannot be seen through the terminus, push music wire through the terminus hole to clear it. Then blow dry air through the hole to remove any debris.

Step 3 - Remove the divider from a 2-part epoxy package and mix the two parts together until the epoxy is a smooth uniform color (see figure 5A1-37). The epoxy can be mixed by either repeatedly rolling the divider over the package or gently sliding the divider over the package.

NOTE: Alternatively, the epoxy may be mixed by massaging the epoxy package by hand.

CAUTION: Do not introduce large air bubbles into the epoxy during the mixing process. Large air bubbles in the epoxy can lead to connector failure during temperature extremes.

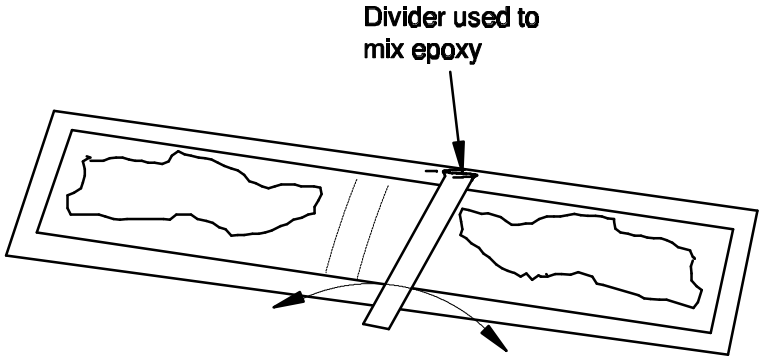


FIGURE 5A1-35. Mixing the epoxy.

Step 4 - Install the syringe tip on the syringe, remove the plunger, and squeeze the epoxy into the syringe. Replace the plunger.

Step 5 - **WARNING:** Wear safety glasses while dispensing the epoxy to avoid possible eye injury.

Remove air pockets in the syringe by holding the tip of the syringe upward and dispensing epoxy onto a wipe until it runs free and clear.

Step 6 - Slide the terminus, rear first, onto the syringe tip (see figure 5A1-36). Keeping the syringe vertical, depress the plunger and slowly inject epoxy into the terminus until it escapes out of the ferrule, forming a very small bead. (NOTE: Do not overfill. Be extremely careful not to get epoxy on the pin spring or other terminus moving parts.)

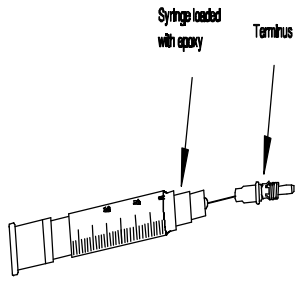


FIGURE 5A1-36. Injecting epoxy into the terminus.

Step 7 - Withdraw the syringe from the terminus. Maintain some pressure on the plunger as the syringe is withdrawn so that the terminus is completely filled with epoxy. Using a wipe dampened with alcohol, wipe away any epoxy on the outer diameter of ferrule without disturbing the epoxy bead.

NOTE: Alternatively, the terminus may be completely filled by maintaining a light pressure on the syringe plunger and allowing the epoxy to push the terminus off of the syringe tip.

Step 8 - Feather the kevlar evenly around the fiber and insert the fiber into the rear of the terminus (see figure 5A1-37). Gently work the fiber through the terminus until the buffer seats against the rear of the ferrule. The OFCC jacket should come up to the rear of the terminus and the kevlar should surround the rear of the terminus. Once inserted, do not allow the fiber to slip back.

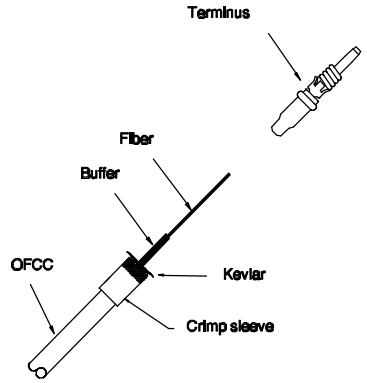


FIGURE 5A1-37. Inserting the fiber into the terminus.

Step 9 - Slide the crimp sleeve over the kevlar and crimp it to the rear of the terminus using the crimp tool. (NOTE: A small amount of epoxy may be added on the kevlar near the rear of the terminus before the crimp sleeve is installed. However, no epoxy should be visible once the crimp sleeve is installed.)

Step 10 - Verify that the kevlar does not protrude excessively from under the crimp sleeve. Excessive kevlar protrusion will cause the terminus to not seat properly in the finished connector. If excessive kevlar protrudes from under the crimp sleeve, trim it back using a razor blade.

Step 11 - Verify that there is a small amount of epoxy around the fiber where it protrudes from the ferrule. If it is found that there is no small bead of epoxy on the terminus tip, carefully add a small amount of epoxy around the fiber. (NOTE: There should only be a small amount of epoxy around the fiber to support it later during the polishing process. If too much epoxy is around the fiber during the curing process it may cause the fiber to crack.)

Step 12 - Using a wipe dampened with alcohol, carefully wipe away any excess epoxy on the fiber that is more than 2 mm (0.08 in) from the ferrule tip surface.

Step 13 - Insert the terminus into the cure adapter until it snaps into place (see figure 5A1-38).

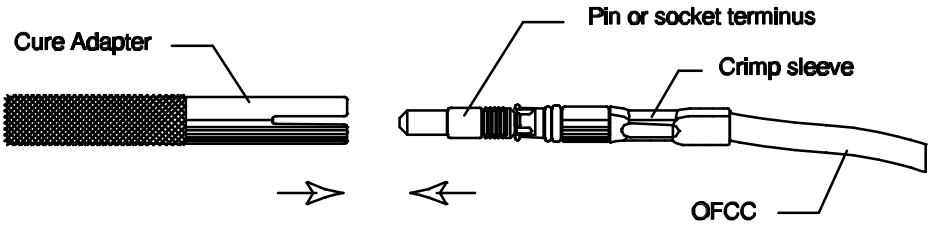


FIGURE 5A1-38. Inserting a terminus in a cure adapter.

Step 14 - Repeat steps 1 through 12 for each fiber to be terminated.

Step 15 - Place the cure adapters in the curing oven, and position the OFCC's vertically over the oven using the cable stand, cable stand ring and cable clip (see figure 5A1-39). Cure the epoxy for a minimum of 10 minutes (maximum of 30 minutes) at 120°C (248°F). (NOTE: When the OFCC's are positioned above the termini, make sure that no bends are placed in the OFCCs. Each OFCC should enter the terminus parallel to the terminus.)

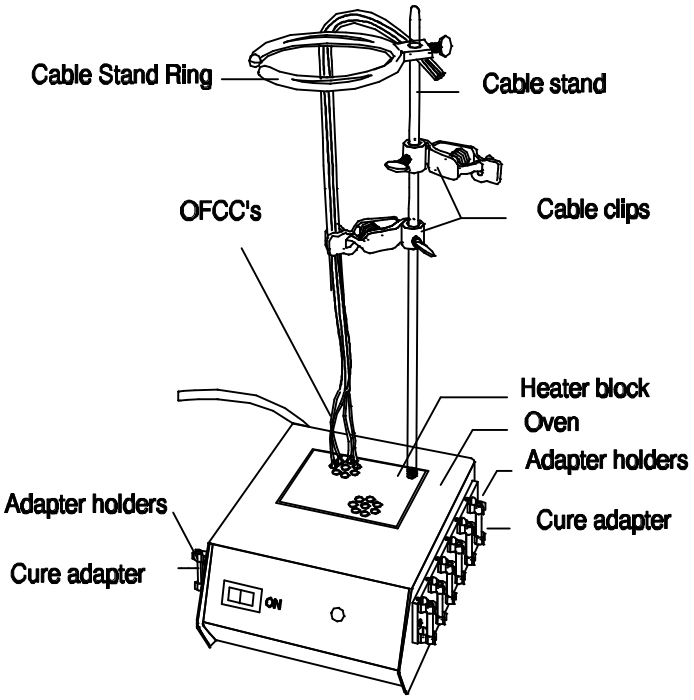


FIGURE 5A1-39. Termini in the curing oven.

Step 16 - Turn the curing oven off and remove the termini from the curing oven. Allow the cure adapters and termini to cool for approximately 4 minutes.

3.4.4 Polishing the fiber ends. Procedures for hand polishing are contained herein. Machine polishing may be used as an alternate method, provided the following requirements are satisfied:

a. The manufacturer's instructions will be rigidly adhered to, except that the polishing papers or disks shall be aluminum oxide 5 µm foam backed and 1 µm mylar backed, as used in hand polishing. (NOTE: Alternate polishing materials may be used if authorized approval is obtained and the polishing machine includes the appropriate stops to prevent changes to the ferrule length.)

b. The machine polished terminus shall undergo the same quality check used for the manually polished terminus as described herein.

NOTE: The procedures contained herein should produce an optical terminus with a physical contact (PC) polish.

Step 1 - **WARNING:** Wear safety glasses when scoring the fiber to avoid possible eye injury.

Remove the terminus from the cure adapter and score the fiber close to the terminus tip at the epoxy interface using one short light stroke with cleaving tool (see figure 5A1-40). (NOTE: Do not break the fibers with the cleaving tool.) Pull off each fiber with a gentle, straight pull. Deposit the waste fiber in a trash container.

NOTE: The termini not being polished should be left in the cure adapters during the polishing process to protect the fibers from breakage.

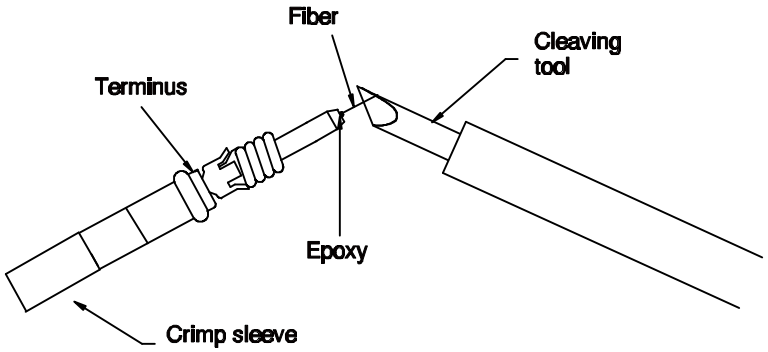


FIGURE 5A1-40. Scoring the fiber.

NOTE: Before inserting the terminus into the polishing tool, the terminus may be held vertically and the end of the fiber polished off by lightly running the 5 µm polishing paper over the top of the terminus tip. (This is referred to as air polishing the terminus.)

Step 2 - Rotate the top half of the polishing tool 90 degrees counterclockwise and separate the top from the base.

Step 3 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-41).

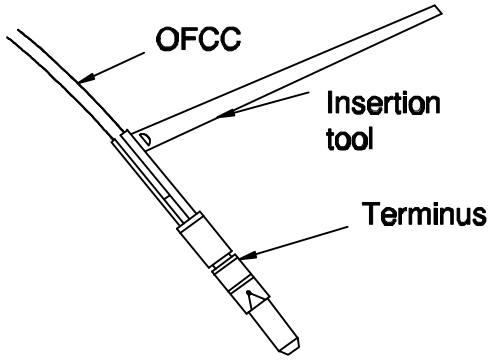


FIGURE 5A1-41. Placing the terminus in the insertion tool.

Step 4 - Insert the terminus into the center of the polishing tool top. Apply pressure with the insertion tool until the terminus snaps into place. Remove the tool by pulling straight back (see figure 5A1-42). (NOTE: Difficulty in inserting the terminus into the polishing tool may indicate epoxy on outside of the terminus which must be removed before proceeding.)

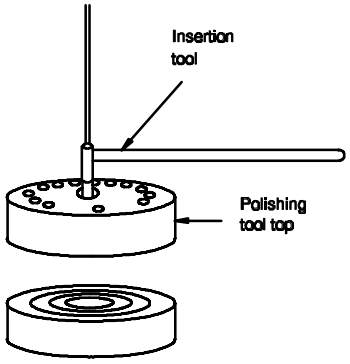


FIGURE 5A1-42. Inserting the terminus in the polishing tool.

Step 5 - Install the top half of the polishing tool on the bottom half and rotate it clockwise (90 degrees) until it locks in place.

Step 6 - Clean the glass polishing plate, the backs of the polishing papers, and the surface of the polishing tool using a wipe dampened with alcohol. Blow all of the surfaces dry with air.

Step 7 - Place the 5 µm polishing paper on the glass plate and start polishing the terminus with very light pressure (the weight of the tool) using a figure-8 motion. Do not overpolish the terminus. (NOTE: The first polish is complete when all of the epoxy is gone from the tip of the terminus.) Since the polishing time varies with the amount of epoxy present on the tip of the terminus, inspect the terminus tip frequently. Whenever the polishing tool is lifted, remove the grit from the tool and the terminus with air. When polishing is complete, clean the terminus and the polishing tool using a wipe dampened with alcohol and blow them dry with air. Perform a rough inspection of the ferrule end using the eye loop.

NOTE: For some ferrule designs all of the epoxy cannot be removed during the first polish and a slight epoxy haze will remain on the ferrule endface. This haze will be removed during the first 5 figure-8 motions of the second polish. If this occurs, polish the connector an additional 5 figure-8 motions during the second polish.

Step 8 - Replace the 5 µm paper with the 1 µm paper. Wet the paper and polish the terminus with very light pressure using a figure-8 motion for 10 to 20 complete motions.

Step 9 - Rotate the top of the polishing tool counterclockwise (90 degrees) and separate the top from the base. Insert the terminus removal tool into the bottom of the terminus cavity of the polishing tool top and press on the hilt of the removal tool until the tool clicks into place (see figure 5A1-43). Depress the plunger and slide the terminus out of the polishing tool. Clean the terminus and the polishing tool with a wipe dampened with alcohol and blow them dry with air.

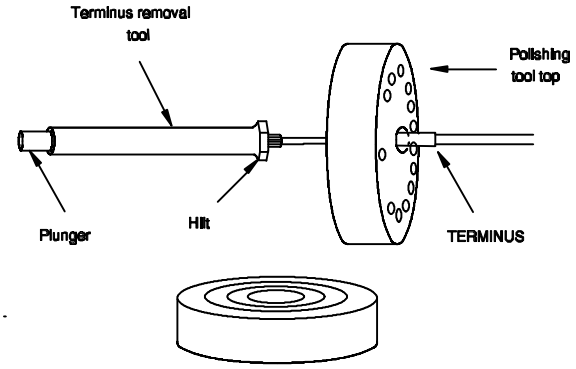


FIGURE 5A1-43. Removing the terminus from the polishing tool.

Step 10 - Repeat steps 1 through 9 for all of the termini.

3.4.5 Quality check.

Step 1 - Examine the terminus with the optical microscope to ensure that the optical surface is smooth and free of scratches, pits, chips, and fractures. If any defects are present, repeat steps 2 through 6, 8, and 9 or reterminate the fiber (see figure 5A1-44). (NOTE: Overpolishing the fiber will increase the optical loss of the terminus. Do not polish the terminus more than necessary to pass the quality check.) A high intensity back light may be used to illuminate the fiber during the quality check.

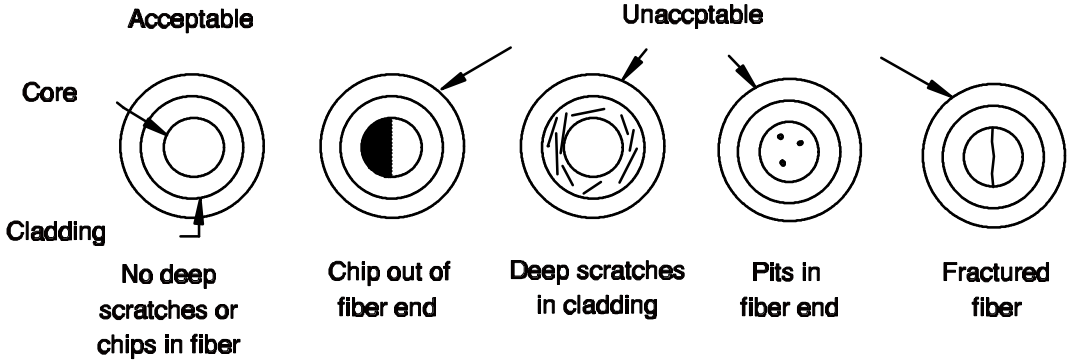


FIGURE 5A1-44. Quality check.

3.4.6 Installation of the terminus into the connector insert.

Step 1 - Place the end of the terminus insertion tool at the rear of the crimp sleeve with the OFCC laid in the tool channel (see figure 5A1-41).

Step 2 - Place the terminus in the proper cavity in the rear of the connector insert. Apply pressure with the insertion tool until the terminus snaps into place (see figure 5A1-45). Remove the tool by pulling straight back. (NOTE: A properly inserted terminus will have some axial "play" within the insert cavity.)

NOTE: A socket terminus, unlike a pin terminus, will require installation of the alignment sleeves after seating the terminus. Proceed to step 3 below for socket termini. For pin termini repeat steps 1 and 2 for the rest of the termini.

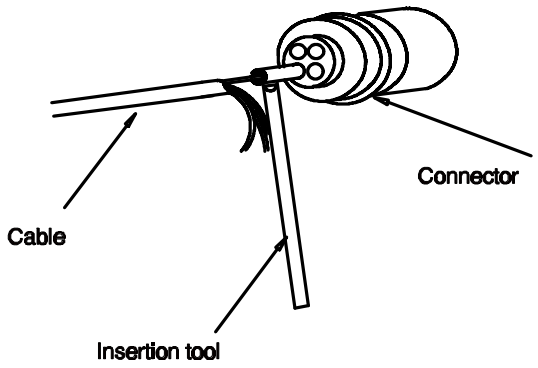


FIGURE 5A1-45. Installing the terminus in the insert.

Step 3 - Place the end of the socket terminus alignment sleeve installation and removal tool into the solid end of the alignment sleeve, depress the plunger to grasp the alignment sleeve, and press the sleeve into the socket terminus cavity in the face of the insert (see figure 5A1-46). Press until the sleeve snaps onto the groove on the ceramic terminus body.

CAUTION: Do not rotate the tool after the sleeve is installed in the insert.

Remove the tool by releasing the plunger and pulling straight back. Proceed to step 4 below.

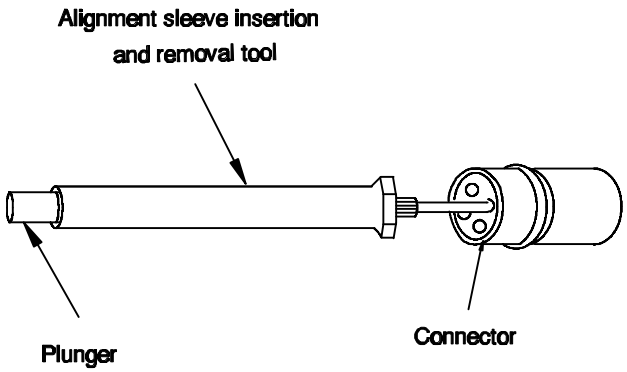


FIGURE 5A1-46. Installing the alignment sleeve.

Step 4 - Repeat steps 1 through 3 for all of the termini.

Step 5 - Install the plastic protective cap over the front of the connector.

3.4.7 Removal of the termini from the connector insert.

NOTE: Perform this procedure only if the termini are to be removed from the connector.

NOTE: Proceed to step 1 below for socket termini. Proceed to step 2 below for pin termini.

Step 1 - **CAUTION:** Do not rotate the tool while the sleeve is in the insert.

Remove the alignment sleeves from the socket termini using the terminus alignment sleeve installation and removal tool by inserting the tool end into the alignment sleeve and depressing the plunger so that the tool grasps the sleeve lip. Pull the sleeve straight back. Proceed to step 2.

Step 2 - Insert the terminus removal tool into the terminus cavity from the front of the insert and press on the hilt of the tool until it snaps into place (see figure 5A1-47). Depress the plunger to slide the terminus out the rear of the insert.

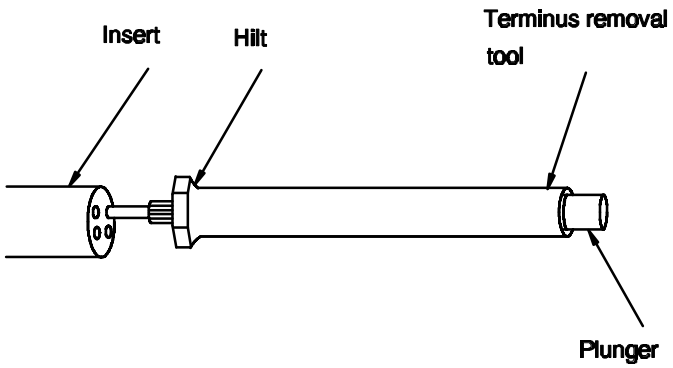


FIGURE 5A1-47. Removing the terminus from the insert.

METHOD 5B1

SINGLE TERMINUS CONNECTOR INSTALLATION

1. SCOPE.

1.1 Scope. This method shall be used for installing MIL-C-83522 single terminus (light duty) connectors onto OFCCs.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 5B1-I shall be used to perform this procedure:

TABLE 5B1-I. Equipment and materials.

Description	Quantity
Wipes (NAVSEA DWG 6872811-18)	As required
Alcohol bottle with alcohol/2-propanol or equal	1
Canned air or compressed air	As required
OFCC strip tool (NAVSEA DWG 6872811-10 or equal)	1
Kevlar shears (NAVSEA DWG 6872811-16)	1
Safety glasses	1
Ruler	1
Buffer strip tool (NAVSEA DWG 6872811-9 or equal)	1
Cleaning wire (NAVSEA DWG 6872811-24 or equal)	As required
Epoxy (MIL-A-24792)	As required
Syringe with dispensing needles (NAVSEA DWG 6872811-22 or equal)	As required
Cure adapters (NAVSEA DWG 6872811-27 or equal)	As required
Crimp tool (NAVSEA DWG 6872811-1 or equal)	1
Die for crimp tool (NAVSEA DWG 6872811-2 or equal)	1
Heat gun (Raychem 500B or equal)	1
Curing oven (NAVSEA DWG 6872811-13 or equal)	1
Holder block	As required
Cleaver (NAVSEA DWG 6872811-7 or equal)	1
Glass polishing plate (NAVSEA DWG 6872811-3 or equal)	1
Polishing paper (5 µm aluminum oxide, foam backed) (NAVSEA DWG 6872811-20 or equal)	As required
Polishing tool (NAVSEA DWG 6872811-4 or equal)	1
Polishing paper (1 µm aluminum oxide, mylar backed) (NAVSEA DWG 6872811-19 or equal)	As required
Water bottle (sealable type)	1
Optical microscope 400X (NAVSEA DWG 6872811-25 or equal)	1
Protective caps (plastic)	As required

CAUTION: Throughout the termination process, cleanliness is critical to obtaining a high optical quality connector. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the connector parts.

NOTE: Verify that the epoxy shelf life has not expired. Do not use epoxy with an expiration date that has passed.

3. PROCEDURE

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers or dispensing epoxy.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Avoid skin contact with epoxies.

d. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

3.2 Procedure.

3.2.1 Cable and fiber preparation.

NOTE: If the cable jacket has not been removed, refer to Method 2A1 and Method 2B1 of Part 2 of this standard.

NOTE: Keep the OFCCs and connector parts free from oil, dirt and grease throughout the installation procedure. If cleaning is necessary, use a wipe dampened with alcohol and blow the part dry with air.

Step 1 - Measure the OFCCs to the required length (refer to the equipment drawings or to Method 2C1 of Part 2 of this standard). Then add sufficient slack to allow for at least two reterminations [40 mm (1.60 inches) of slack should be sufficient for one retermination].

Step 2 - Slip the heat shrink tubing (with the fiber identification), the connector boot and the crimp sleeve over the OFCC (see figure 5B1-1).

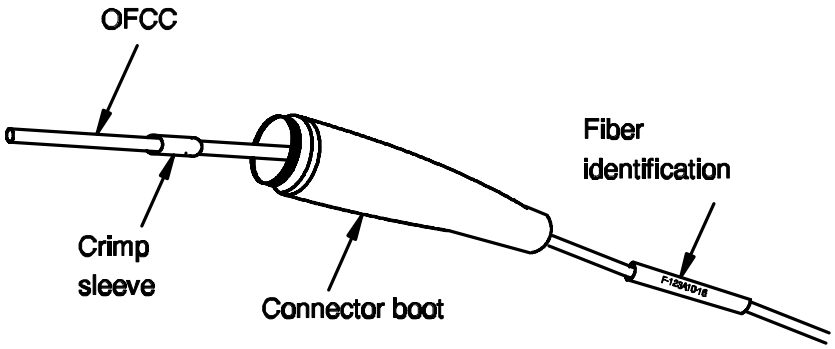


FIGURE 5B1-1. Installing the identification sleeve and connector boot - (typical).

Step 3 - Remove the OFCC jacket back 33 mm (1.30 in) from the end of the fiber using the OFCC stripper and trim the OFCC kevlar with the kevlar shears so that approximately 6 mm (0.25 in) extends past the OFCC jacket (see figure 5B1-2).

Step 4 - **WARNING:** Wear safety glasses when removing the fiber buffer and coating to avoid possible eye injury.

Mark the fiber buffer 20 mm (0.80 in) back from the end of the fiber and remove the fiber buffer and coating back to the mark using the buffer stripper (see figure 5B1-2). Remove the buffer and coating in small sections (approximately 6 mm (0.25 in) at a time.) (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

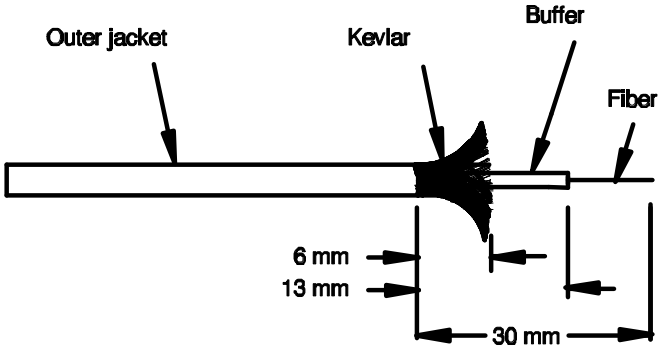


FIGURE 5B1-2. Prepared OFCC dimensions.

Step 5 - **CAUTION:** The uncoated fiber is in its most vulnerable state. Take extreme care not to damage the fiber.

Remove any residual coating material from the bare fiber with a wipe dampened with alcohol. Wipe once from the end of the buffer towards the end of the fiber. (NOTE: Do not repeatedly wipe the bare fiber as this will weaken the fiber.)

3.3.2 Installation of the connector onto the fiber.

Step 1 - Inspect the connector and verify that the ferrule hole is free and clean of dirt. This can be accomplished by holding the front of the connector up to a light and verifying that the light is visible from the rear of the connector. If light cannot be seen through the connector, push music wire through the ferrule hole to clear it. Then blow dry air through the hole to remove any debris.

Step 2 - Remove the divider from a 2-part epoxy package and mix the two parts together until the epoxy is a smooth uniform color (see figure 5B1-3). The epoxy can be mixed by either repeatedly rolling the divider over the package or gently sliding the divider over the package.

NOTE: Alternatively, the epoxy may be mixed by massaging the epoxy package by hand.

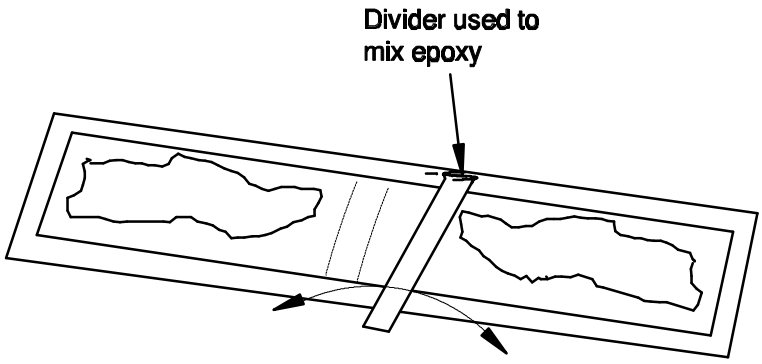


FIGURE 5B1-3. Mixing the epoxy.

CAUTION: Do not introduce large air bubbles into the epoxy during the mixing process. Large air bubbles in the epoxy can lead to connector failure during temperature extremes.

Step 3 - Install the syringe tip on the syringe, remove the plunger, and squeeze the epoxy into the syringe. Replace the plunger.

Step 4 - **WARNING:** Wear safety glasses while dispensing the epoxy to avoid possible eye injury.

Remove air pockets in the syringe by holding the tip of the syringe upward and dispensing epoxy onto a wipe until it runs free and clear.

Step 5 - Slide the connector, rear first, onto the syringe tip (see figure 5B1-4). Depress the plunger and slowly inject epoxy into the connector until it escapes out of the ferrule, forming a very small bead. (NOTE: Do not overfill. Be extremely careful not to get epoxy on the connector spring or other connector moving parts.)

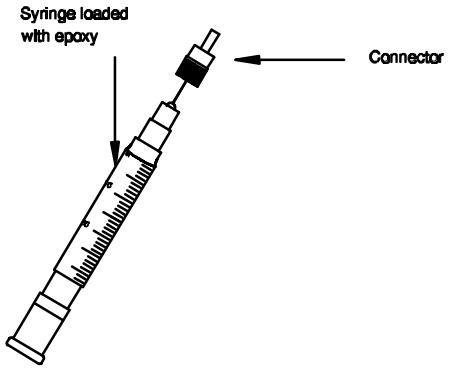


FIGURE 5B1-4. Injecting epoxy into the connector.

Step 6 - Withdraw the syringe from the connector. Maintain some pressure on the plunger as the syringe is withdrawn so that the connector is completely filled with epoxy. Using a wipe dampened with alcohol, wipe away any epoxy on the outer diameter of the ferrule without disturbing the epoxy bead.

NOTE: Alternatively, the connector may be completely filled by maintaining a light pressure on the syringe plunger and allowing the epoxy to push the connector off of the syringe tip.

Step 7 - Apply a very thin coating of epoxy to the kevlar strands and the buffer.

Step 8 - Apply a very thin band of epoxy to approximately 3 mm (0.12 inch) of the connector barrel (see figure 5B1-5).

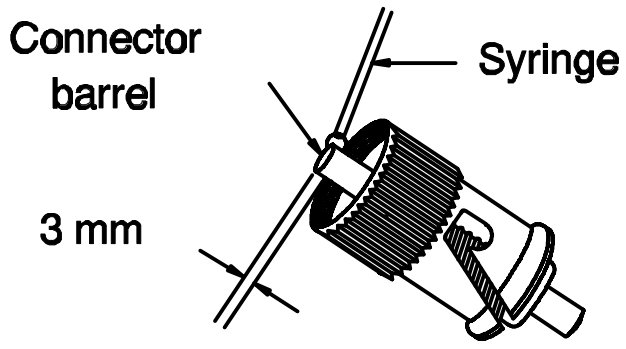


FIGURE 5B1-5. Applying epoxy to the connector barrel.

Step 9 - Feather the kevlar evenly around the fiber and insert the fiber into the rear of the connector (see figure 5B1-6). Gently work the fiber through the connector until the buffer seats against the rear of the ferrule. The OFCC jacket should come up to the rear of the connector barrel and the kevlar should surround the rear of the connector barrel. Once inserted, do not allow the fiber to slip back.

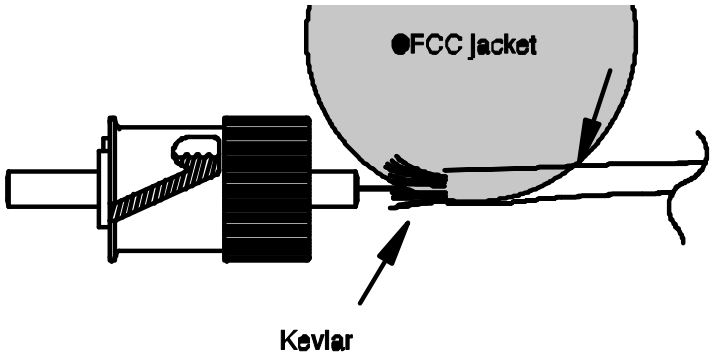


FIGURE 5B1-6. Inserting the fiber into the connector.

Step 10 - Carefully place the cure adapter over the fiber and mate it to the connector so that the connector barrel is at maximum extension from the rear of the connector (place the cure adapter nub at end of the connector ramp, just before the normal mated position). Slide the crimp sleeve over the OFCC jacket and kevlar onto the connector barrel (see figure 5B1-7).

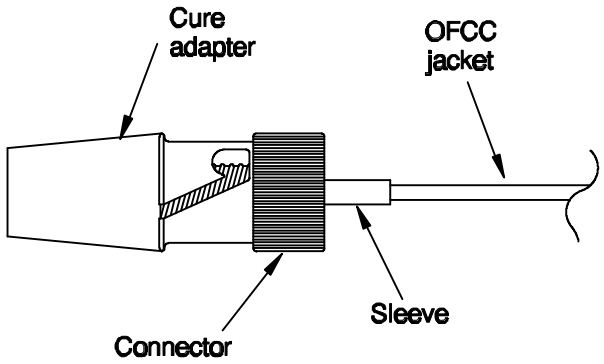


FIGURE 5B1-7. Sliding the crimp sleeve over the connector barrel.

NOTE: The fiber must not protrude beyond the end of the cure adapter. If it does, trim the fiber end so it does not.

Step 11 - Place the crimping tool over the crimp sleeve and crimp it against the connector barrel. Rotate the connector 90 degrees and crimp it again (see figure 5B1-8).

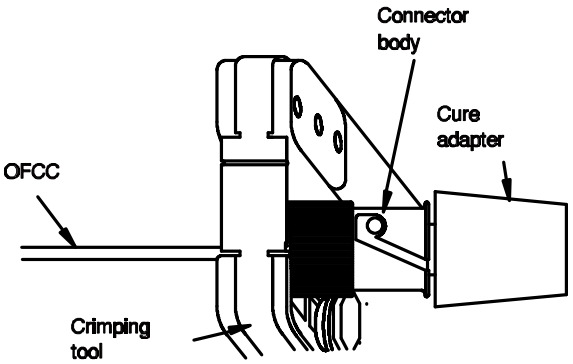


FIGURE 5B1-8. Crimping the connector.

Step 12 - Verify that there is a small amount of epoxy around the fiber where it protrudes from the ferrule. If it is found that there is no small bead of epoxy on the ferrule tip, carefully add a small amount of epoxy around the fiber. (NOTE: There should only be a small amount of epoxy around the fiber to support it later during the polishing process. If too much epoxy is around the fiber during the curing process it may cause the fiber to crack.)

Step 13 - Using a wipe dampened with alcohol, carefully wipe away any epoxy on the fiber that is more than 2 mm (0.08 in) from the ferrule surface.

Step 14 - Apply a drop of epoxy onto the rubber boot threads, slip the boot over the crimped sleeve and screw it onto the connector body.

Step 15 - **CAUTION:** Do not overheat the OFCC. Prolonged exposure of the OFCC to temperatures above 160°C (320°F) may damage the OFCC jacket. Discontinue heating of the tubing and allow the jacket to cool before reheating if the jacket shows any signs of bubbling.

Slide the fiber identification tubing up the OFCC to near the connector boot and shrink it over the OFCC using a heat gun.

3.2.3 Curing the epoxy.

Step 1 - Turn on the curing oven so that it attains the proper temperature before the connector is placed within it (approximately 20 minutes).

Step 2 - Place the cure adapter with the connector in the curing oven, and position the OFCC vertically over the oven. Cure the epoxy for a minimum of 10 minutes (maximum of 30 minutes) at 120°C (248°F). (NOTE: When the OFCC is positioned above the connector, make sure that no bends are placed in the OFCC. The OFCC should enter the connector parallel to the connector axis.)

Step 3 - Turn the curing oven off, remove the connector and cure adapter from the curing oven, and place them on a cure adapter holder block or non-flammable surface. Allow the cure adapter and connector to cool for approximately 4 minutes.

3.2.4 Polishing the fiber ends. Procedures for hand polishing are contained herein. Machine polishing may be used as an alternate method, provided the following requirements are satisfied:

a. The manufacturer's instructions will be rigidly adhered to, except that the polishing papers or disks shall be aluminum oxide 5 µm foam backed and 1 µm mylar backed, as used in hand polishing. (NOTE: Alternate polishing materials may be used if authorized approval is obtained and the polishing machine includes the appropriate stops to prevent changes to the ferrule length.)

b. The machine polished connector shall undergo the same quality check used for the manually polished connector as described herein.

NOTE: The procedures contained herein should produce an optical terminus with a physical contact (PC) polish.

Step 1 - **WARNING:** Wear safety glasses when scoring the fiber to avoid possible eye injury.

Remove the connector from the cure adapter and score the fiber close to the ferrule tip at the epoxy interface using one short light stroke with cleaving tool (see figure 5B1-9). (NOTE: Do not break the fiber with the cleaving tool.) Pull off the fiber with a gentle, straight pull. Deposit the waste fiber in a trash container.

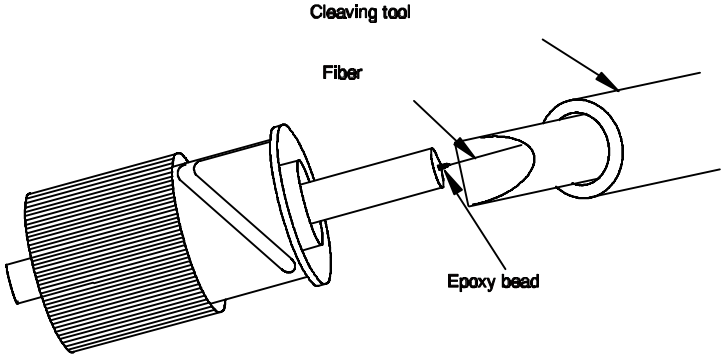


FIGURE 5B1-9. Scoring the fiber.

Step 2 - Clean the glass polishing plate, the backs of the polishing papers, and the surface of the polishing tool using a wipe dampened with alcohol. Blow all of the surfaces dry with air.

NOTE: Before inserting the connector into the polishing tool, the connector may be held vertically and the end of the fiber polished off by lightly running the 5 µm polishing paper over the top of the ferrule tip. (This is referred to as air polishing the connector.)

Step 3 - Insert the connector into the polishing tool (see figure 5B1-10). (NOTE: Difficulty in inserting the connector ferrule into the polishing tool may indicate epoxy on outside of the ferrule which must be removed before proceeding.)

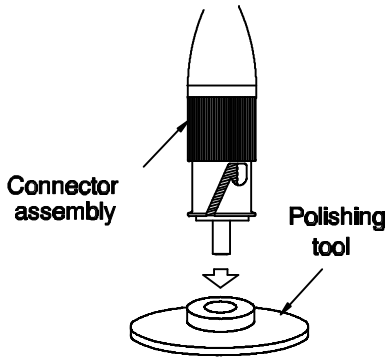


FIGURE 5B1-10. Inserting the connector into the polishing tool.

Step 4 - Place the 5 µm polishing paper on the glass plate and start polishing the connector with very light pressure (the weight of the tool) using a figure-8 motion (see figure 5B1-11). Do not overpolish the connector. (NOTE: The first polish is complete when all of the epoxy is gone from the tip of the ferrule.) Since the polishing time varies with the amount of epoxy present on the tip of the ferrule, inspect the ferrule tip frequently. Whenever the polishing tool is lifted, remove the grit from the tool and the ferrule with air. When polishing is complete, clean the ferrule and the polishing tool using a wipe dampened with alcohol and blow them dry with air.Perform a rough inspection of the ferrule end using the eye loop.

NOTE: For some ferrule designs all of the epoxy cannot be removed during the first polish and a slight epoxy haze will remain on the ferrule endface. This haze will be removed during the first 5 figure-8 motions of the second polish. If this occurs, polish the connector an additional 5 figure-8 motions during the second polish.

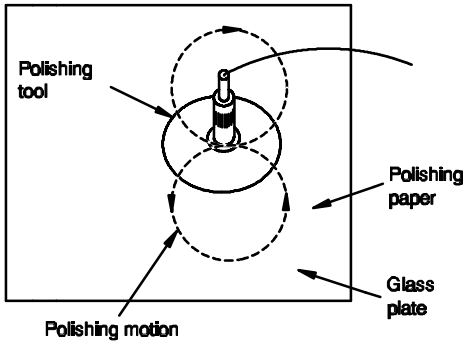


FIGURE 5B1-11. Polishing the connector.

Step 5 - Replace the 5 µm paper with the 1 µm paper. Wet the paper and polish the connector with very light pressure using a figure-8 motion for 10 to 20 complete motions.

Step 6 - Remove the connector from the polishing tool, clean it using a wipe dampened with alcohol and blow it dry with air.

3.2.5 Quality check.

Step 1 - Examine the connector with the optical microscope to ensure that the optical surface is smooth and free of scratches, pits, chips, and fractures. If any defects are present, repeat steps 2, 3, 5 and 6 or reterminate the fiber (see figure 5B1-12). (NOTE: Overpolishing the fiber will increase the optical loss of the connector. Do not polish the connector more than necessary to pass the quality check.) A high intensity back light may be used to illuminate the fiber during the quality check.

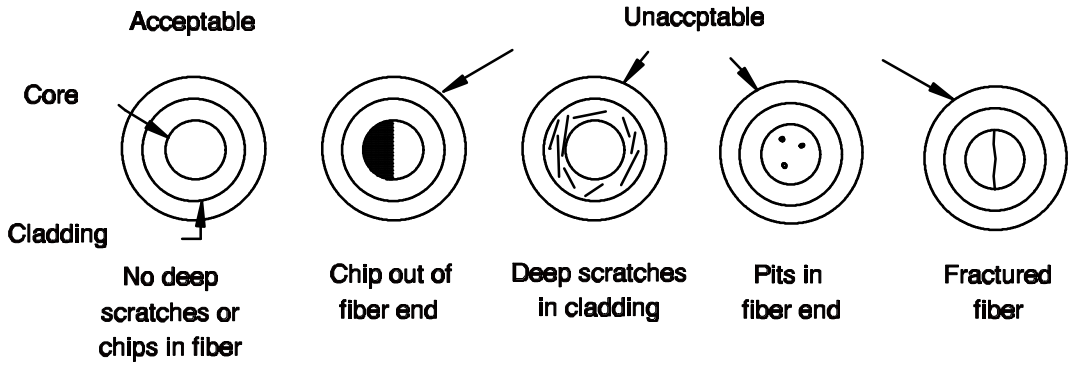


FIGURE 5B1-12. Quality check.

Step 2 - If the connector is not to be immediately mated into an adapter, install a plastic protective cap over the connector ferrule.

METHOD 5C1

MECHANICAL SPLICE FERRULE INSTALLATION

1. SCOPE.

1.1 Scope. This method describes a procedure for installing a MIL-S-24623/4 mechanical splice ferrule onto an OFCC.

NOTE: The MIL-S-24623/4 splice is a commercial based fiber splice commonly called a rotary mechanical splice. However, all commercial rotary mechanical splices are **not** compatible with the MIL-S-24623/4 splice. Only commercial rotary mechanical splices with ferrule diameters between 2.4996 mm and 2.5006 mm (AT&T letter code "M") are compatible with the MIL-S-24623/4 splice.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 5C1-I shall be used to perform this procedure:

TABLE 5C1-I. Equipment and materials.

Description	Quantity
Wipes (NAVSEA DWG 6872812-18 or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air or compressed air	As required
OFCC strip tool (NAVSEA DWG 6872812-10 or equal)	1
Kevlar shears (NAVSEA DWG 6872812-16 or equal)	1
UV absorbing safety glasses	1
Buffer strip tool (NAVSEA DWG 6872812-9 or equal)	1
UV cure adhesive (MIL-A-24793)	As required
Dispensing needles (NAVSEA DWG 6872812-22 or equal)	As required
UV blocking shield	As required
UV curing lamp and base (NAVSEA DWG 6872812-13 or equal)	1
Cleaver (NAVSEA DWG 6872812-7 or equal)	1
Utility knife	1
Glass polishing plate (NAVSEA DWG 6872812-3 or equal)	1
Polishing paper, 8 µm, aluminum oxide, paper backed (NAVSEA DWG 6872812-19 or equal)	As required
Polishing paper, 0.3 µm, aluminum oxide, paper backed (NAVSEA DWG 6872812-20 or equal)	As required
Polishing tool (NAVSEA DWG 6872812-4 or equal)	1
Water bottle (sealable type)	1
7x eye loupe	1
Protective caps (plastic)	As required

CAUTION: Throughout the termination process, cleanliness is critical to obtaining a high optical quality splice. Make sure that your hands and the work area are as clean as possible to minimize the ingress of dirt into the splice.

NOTE: Verify that the adhesive and index matching material shelf life has not expired. Do not use adhesive or index matching material with an expiration date that has passed.

3. PROCEDURE.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn at all times when handling bare fibers or dispensing adhesive.

b. Do not touch the ends of the fiber as they may be razor sharp. Wash your hands after handling bare fiber.

c. Avoid skin contact with adhesives.

d. Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

e. Ultraviolet (UV) safety glasses shall be worn when using the UV curing lamp.

3.2 Procedure.

3.2.1 Cable and fiber preparation.

NOTE: If the cable jacket has not been removed, refer to Method 2A1 and Method 2B1 of Part 2 of this standard.

NOTE: Keep the OFCCs and splice parts free from oil, dirt and grease throughout the installation procedure. If cleaning is necessary, use a wipe dampened with alcohol and blow the part dry with air.

Step 1 - Measure the OFCCs to the required length (refer to the equipment drawings or to Method 2C1 of Part 2 of this standard). Then add sufficient slack to allow for at least two reterminations [40 mm (1.60 inches) of slack should be sufficient for one retermination].

Step 2 - Slip the heat shrink tubing with the fiber identification over the OFCC.

Step 3 - Measure the distance from the expected splice position in the splice tray to the last OFCC tie down location, add approximately 60 mm (2.4 inches) and mark the OFCC jacket. Using the OFCC stripper, remove the OFCC jacket back to the mark.

Step 4 - Separate the kevlar strands from the buffered fiber and, using the kevlar shears, trim the strands back to the OFCC jacket edge.

Step 5 - **WARNING:** Wear safety glasses when removing the fiber buffer and coating to avoid possible eye injury.

Mark the fiber buffer 30 mm (1.20 in) back from the end of the fiber, and remove the fiber buffer and coating back to the mark using the buffer stripper. Remove the buffer and coating in small sections (approximately 6 mm (0.25 in) at a time.) (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

Step 6 - **CAUTION:** The uncoated fiber is in its most vulnerable state. Take extreme care not to damage the fiber.

Remove any residual coating material from the bare fiber with a wipe dampened with alcohol. Wipe only once from the end of the buffer towards the end of the fiber. (NOTE: Do not repeatedly wipe the bare fiber as this will weaken the fiber.)

3.2.2 Installation of the ferrules onto the fibers.

Step 1 - Separate the ferrules by grasping both sides of an assembled ferrule pair with the thumb and index fingers. Simultaneously pull and slightly bend the ferrules until they separate. (NOTE: Do not twist the ferrules during separation.)

Note: If the ferrules are already separated and matching ferrule sets are not obvious, inspect the ferrules to verify that all of the ferrules are MIL-S-24623/4 ferrules. Unmatched ferrules can be mated with no reduction in optical performance only if the ferrules are MIL-S-24623/4.

Step 2 - Install the syringe tip on the UV adhesive syringe.

Step 3 - Cover the entire ferrule assembly with a UV blocking shield if the splicing procedure will be performed in direct or bright sunlight or under bright fluorescent lamps (NOTE: Normal ship lighting is not bright enough to cause the UV adhesive to cure prematurely.)

Step 4 - **WARNING:** Wear safety glasses when dispensing epoxy to avoid possible eye injury.

Insert the tip of the syringe into rear of the splice ferrule until the syringe tip bottoms out. Slowly inject adhesive into the ferrule until a very small bead appears on the ferrule tip (see figure 5C1-1). (NOTE: Be extremely careful not to get adhesive on the splice spring or other splice moving parts.)

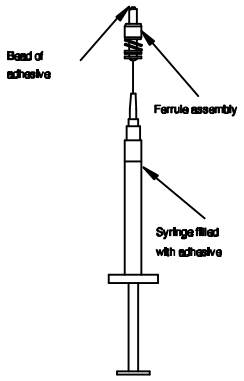


FIGURE 5C1-1. Injecting adhesive into the ferrule.

Step 5 - Withdraw the syringe from the splice. Maintain some pressure on the plunger as the syringe is withdrawn so that the splice is completely filled with adhesive. Using a wipe dampened with alcohol, wipe away any adhesive on the outer diameter of the ferrule without disturbing the ferrule end. Place the syringe under a UV blocking shield or wipe.

Step 6 - Carefully insert the stripped fiber into the ferrule until the buffer bottoms out (see figure 5C1-2). Once inserted, do not allow the fiber to slip back.

Step 7 - Verify that there is a small amount of adhesive around the fiber where it protrudes from the ferrule. If it is found that there is no small bead of adhesive on the ferrule tip, carefully add a small amount of adhesive around the fiber. (NOTE: There should only be a small amount of adhesive around the fiber to support it later during the polishing process.)

Step 8 - Using a wipe dampened with alcohol, carefully wipe away any adhesive on the fiber that is more than 2 mm (0.08 in) from the ferrule surface.

3.2.3 Curing the adhesive.

Step 1 - Remove the UV blocking shield, if it was used.

Step 2 - Place the prepared ferrule on the curing lamp base. Position the UV curing lamp over the ferrule (see figure 5C1-3). Do not allow the ferrule to slide forward off of the fiber buffer. (NOTE: If

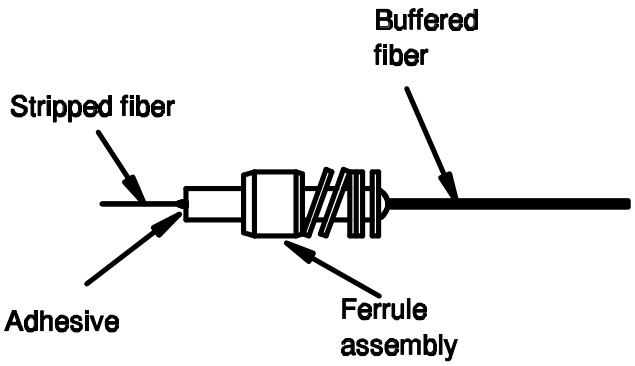


FIGURE 5C1-2. Inserting the fiber into the ferrule.

possible, tape the OFCC's and the buffered fiber to any available surface during the curing period to avoid accidentally pulling the fibers out of the ferrules or the ferrules out from under the curing lamp.)

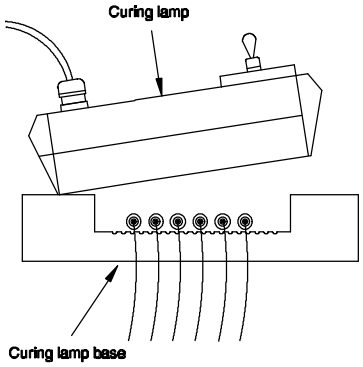


FIGURE 5C1-3. Positioning the curing lamp.

Step 3 - **WARNING:** Wear UV safety glasses when using the curing lamp to avoid possible eye injury.

Turn on the curing lamp and cure the ferrules for a minimum of 2 minutes (maximum of 7 minutes).

Step 4 - Turn off the curing lamp and lift it off the curing lamp base. Remove the cured ferrules from curing lamp base.

3.2.4 Polishing the fiber ends. Procedures for hand polishing are contained herein. Machine polishing may be used as an alternate method, provided the following requirements are satisfied:

a. The manufacturer's instructions will be rigidly adhered to, except that the polishing papers or disks shall be 8 µm paper backed and 0.3 µm paper backed, as used in hand polishing. (NOTE: Alternate polishing materials may be used if authorized approval is obtained from the contracting activity.)

b. The machine polished ferrule shall undergo the same quality check used for the manually polished ferrule as described herein.

Step 1 - **WARNING:** Wear safety glasses when scoring the fiber to avoid possible eye injury.

Score the fiber close to the ferrule tip at the epoxy interface using one short light stroke with cleaving tool (see figure 5C1-4). (NOTE: Do not break the fiber with the cleaving tool.) Pull off the fiber with a gentle, straight pull. Deposit the waste fiber in a trash container.

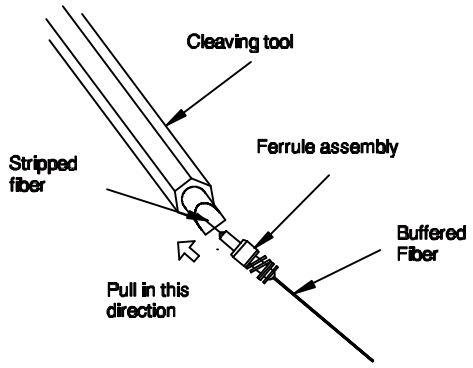


FIGURE 5C1-4. Scoring the fiber.

Step 2 - Remove any adhesive on the cylindrical surface of the ferrule using a utility knife. Move the knife from the back to the front of the ferrule using a light force and a shallow working angle (see figure 5C1-5). (NOTE: Be careful not to scratch the ferrule end.)

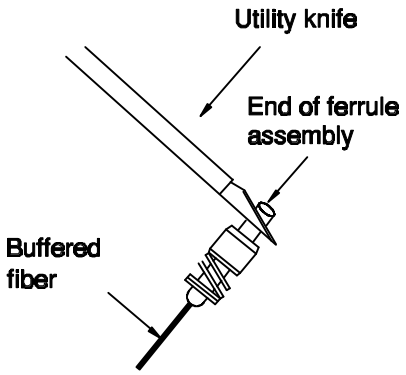


FIGURE 5C1-5. Removing the excess adhesive.

Step 3 - Clean the glass polishing plate, the backs of the polishing papers, and the surface of the polishing tool using a wipe dampened with alcohol. Blow all of the surfaces dry with air.

Step 4 - Insert the ferrule into the polishing tool.

Step 5 - Place the 8 µm polishing paper on the glass plate. Wet the paper and start polishing the ferrule with very light pressure (the weight of the tool) using a figure-8 motion (see figure 5C1-6). Polish the ferrule until the adhesive is gone and the ferrule surface is unmarked. Since the polishing time varies with the amount of adhesive present on the tip of the ferrule, inspect the ferrule tip frequently using the eye loupe. Whenever the polishing tool is lifted, remove the grit from the tool and the ferrule with air.

Step 6 - Replace the 8 µm paper with the 0.3 µm paper. Wet the paper and polish the connector with very light pressure using a figure-8 motion for 5 to 10 complete motions.

NOTE: Do not over polish; 10 figure-8's should be adequate.

Step 7 - Remove the ferrule from the tool and clean both with a wipe dampened with alcohol and blow dry with air.

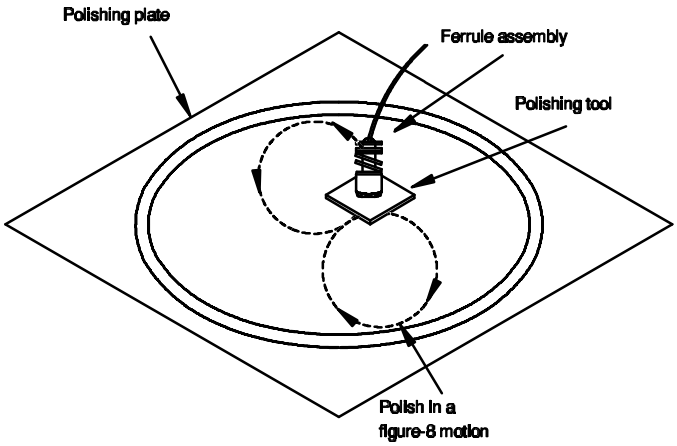


FIGURE 5C1-6. Polishing the ferrule.

3.2.5 Quality check.

Step 1 - Examine the ferrule with the eye loupe to ensure that the optical surface is smooth and free of scratches, pits, chips, and fractures (see figure 5C1-7). If any defects are present, repeat steps 3, 4, 6 and 7 or reterminate the fiber. (NOTE: Overpolishing the fiber will increase the optical loss of the splice. Do not polish the ferrule more than necessary to pass the quality check.)

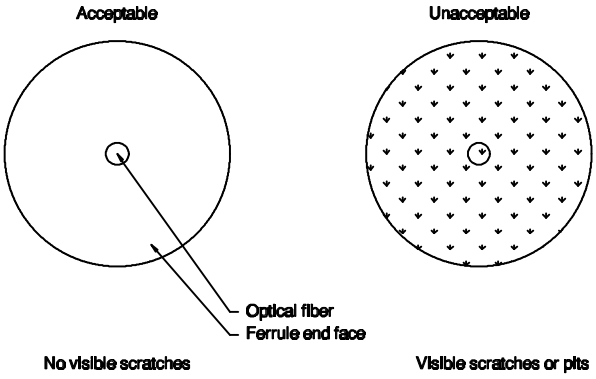


FIGURE 5C1-7. Quality check.

Step 2 - If the splice is not to be immediately mated in an alignment clip, install a plastic protective cap over the splice ferrule.

NOTE: This draft, dated 14 August 1995, prepared by the Naval Sea Systems Command, has not been approved and is subject to modification. DO NOT USE FOR ACQUISITION PURPOSES. (Project GDRQ-NXXX)

MIL-STD-2042-6A(SH)

SUPERSEDING
MIL-STD-2042-6(SH)
7 July 1993

MILITARY STANDARD

FIBER OPTIC CABLE TOPOLOGY INSTALLATION STANDARD METHODS FOR NAVAL SHIPS (TESTS)

(PART 6 OF 6 PARTS)

AMSC N/A AREA GDRQ

FOREWORD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03K12, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard provides detailed information and guidance to personnel concerned with the installation of fiber optic cable topologies (fiber optic cabling and associated components) on Naval surface ships and submarines. The methods specified herein are not identifiable to any specific ship class or type, but are intended to standardize and minimize variations in installation methods to enhance the compatibility of the installations on all Naval ships.

4. In order to provide flexibility in the use and update of the installation methods, this standard is issued in seven parts; the basic Standard and six numbered parts as follows:

Part 1 Cables
Part 2 Equipment
Part 3 Cable Penetrations
Part 4 Cableways
Part 5 Connectors and Interconnections
Part 6 Tests

CONTENTS

CONTENTS

1. SCOPE

1.1 Scope. This standard provides detailed methods for testing fiber optic cable topology (see 3.2) installations.

1.1.1 Applicability. These procedures apply to fiber optic cables, connectors and splices and shall be performed during the installation phases specified. Where there is a conflict between this document and the ship specification or contract, the ship specification or contract shall take precedence. Where ship design is such that the methods herein cannot be implemented, users shall submit new methods or modifications to existing methods to NAVSEA 03K12 for approval prior to implementation.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-S-24623/4	- Splice, Fiber Optic, Housing, Fiber.
MIL-C-28876	- Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini, General Specification for.
MIL-T-29504	- Termini, Fiber Optic Connector, Removable, General Specification for.
MIL-C-83522	- Connectors, Fiber Optic, Fixed Single Terminus, General Specification for.
MIL-C-85045	- Cable, Fiber Optic, (Metric) General Specification for.

STANDARDS

MILITARY

MIL-STD-2042-1	- Fiber Optic Topology Installation Standard Methods for Naval Ships (Cables)(Part 1 of 6 Parts).
MIL-STD-2042-2	- Fiber Optic Topology Installation Standard Methods for Naval Ships (Equipment)(Part 2 of 6 Parts).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave, Philadelphia, PA, 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

NAVSEA Drawing	- 6872811 Tool Kit, MIL-C-83522, Fiber Optic, Navy Shipboard.
	- 6872812 Tool Kit, MIL-S-24623, Fiber Optic, Navy Shipboard.
	- 6877804 Jumpers, Test Equipment, Fiber Optic.

(Copies of documents should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z136.2	- Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

ELECTRONICS INDUSTRY ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION

EIA/TIA-455-61	-	Measurement of Fiber or Cable Attenuation Using an OTDR.
EIA/TIA-455-171	-	Attenuation by Substitution Measurement for Short Length Multimode Graded Index and Single mode Optical Fiber Cable Assemblies.
EIA/TIA-440	-	Fiber Optic Terminology.

(Application for copies should be addressed to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General fiber optics terms. Definitions for general fiber optics terms used in this standard are in accordance with EIA/TIA-440. Definitions for other terms as they are used in this standard are given in the following paragraphs.

3.2 Fiber optic cable topology. The fiber optic cable topology consists of fiber optic interconnection boxes, trunk and local cables and the connectors and splices used to interconnect the trunk and local cables.

3.3 Concatenated optical link. A concatenated optical link is a link made up of two or more individual cable assemblies connected together in series.

3.4 Trunk cable. A trunk cable is a fiber optic cable that provides a continuous optical path between interconnection boxes. Typically, trunk cables are run in the main cableways and have higher fiber counts per cable than local cables.

3.5 Local cable. A local cable is a fiber optic cable that provides a continuous optical path between an interconnection box (or outlet) and an end user equipment or between an interconnection box and an outlet, and is typically not run through the main cableways.

3.6 Optical fiber cable component (OFCC). An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket.

3.7 Outlet. An outlet is a small termination box used to break out a local cable from an interconnection box to one or more equipments within a compartment.

3.8 End user equipment. End user equipment refers to any cabinet, case, panel, or device that contains components that are either the origin or destination of an optical signal.

3.9 Measurement quality jumper. A measurement quality jumper is a jumper cable that is of high optical quality, is highly repeatable in successive connections, and is consistent with other measurement quality jumpers in connections.

4. GENERAL REQUIREMENTS

4.1 Test methods. The test methods identified in this standard shall be used to verify the proper operation and performance of the components that make up the fiber optic cable topology (see 3.2). These tests shall be performed during various phases of installation of the fiber optic cable topology, as described in the following paragraphs.

4.1.1 Acceptance tests. Fiber optic cable and associated components shall undergo visual inspection and testing upon receipt at the shipyard. The cable shall be tested while still on the shipping reel to ensure that it is mechanically and optically sound. The associated fiber optic components shall be subjected to visual examination only.

4.1.2 Pre-Installation tests. Visual inspection and testing of the cable shall be conducted just prior to installation in the cableways to verify that it is still mechanically and optically sound.

4.1.3 Installation tests. After the cable is installed in the cableways, the pre-installation tests shall be repeated to verify that fibers were not broken or damaged when the cable was pulled through the cableways. Additional testing shall be conducted subsequent to installation of connectors or splices to ensure that the optical losses induced by these components are within acceptable limits and that the continuity of each fiber between interconnection devices has been maintained.

4.1.4 Post-Installation tests. After all fiber optic cable topology links have been installed, tests shall be conducted to verify that the end-to-end attenuation of the fiber optic cable topology is within specified limits.

4.2 Test equipment. The following paragraphs discuss optical test equipment in general terms only. The specific equipment to be used for each test is identified in the individual test methods of section 5.

4.2.1 Optical time domain reflectometer (OTDR). The OTDR is used for :

a. Estimating the attenuation rate of a fiber;

b. Identifying the nature and location of defects in an optical link.

4.2.2 Optical power meter and stabilized light source. The optical power meter and stabilized light source (for example, portable light emitting diode (LED) or laser diode) are used together to make accurate optical transmission loss measurements. Test jumpers are used to couple light from the stabilized source to the optical link under test, and from the fiber path to the power meter. It is imperative that these test jumpers contain the same type of fiber and connectors as the optical link and meet the requirements identified in Method 6F1 of this standard.

4.2.3 Optical loss test set (OLTS). The OLTS combines the optical power meter and stabilized light source (see 4.2.2) into a single unit. The OLTS displays the transmission loss directly by comparing the optical power level of the source with the optical power level transmitted through the optical link under test.

4.2.4 Optical talk set. The optical talk set is used to establish two-way voice communication over an optical fiber. The talk set can be used to verify optical link continuity and to expedite other tests.

4.2.5 Measurement quality jumpers. Measurement quality jumpers are required for connecting cable assemblies to test equipment. Measurement quality jumpers may be acquired using NAVSEA DWG 6877804. Typical jumper configurations are shown in table I. Cable assembly cables shall be in accordance with MIL-C-85045. Terminations shall be in accordance with the following:

a. Single terminus (light duty) connector, MIL-C-83522/16

b. Multiple terminus (heavy duty) connector, MIL-C-28876

c. Connector terminus, MIL-T-29504/14 or /15

d. Splice ferrule, MIL-S-24623/4

The jumpers used in conjunction with an OTDR should be long enough (typically 50 meters (165 feet)) to compensate for the inability of the OTDR to make accurate measurements on short lengths [less than 50 m (165 feet)] of fiber.

TABLE I. Test jumper configurations.

CONFIGURATION	TERMINATION TYPE	LENGTH (min) (m)	CABLE TYPE M85045/	TERMINATION 1	TERMINATION 2
A	ST/ST	1	16-01	M83522/16-DNX	M83522/16-DNX
B	ST/SPLICE FERRULE	1	16-01	M83522/16-DNX	M24623/4-01
C	ST/4 CH PLUG	1	15-01	M83522/16-DNX	Packard Hughes 1145846-B042P0S
D	ST/4 CH RECEPT	1	15-01	M83522/16-DNX	Packard Hughes 1145840-B042S0S
E	ST/8 CH PLUG	1	13-01	M83522/16-DNX	Packard Hughes 1145846-C081P0S
F	ST/8 CH RECEPT	1	13-01	M83522/16-DNX	Packard Hughes 1145840-C081S0S
G	ST/ST LONG	50	16-01	M83522/16-DNX	M83522/16-DNX
H	ST/SPLICE FERRULE	50	16-01	M83522/16-DNX	M24623/4-01
I	ST/PIN TERMINUS	50	16-01	M83522/16-DNX	M29504/14-4131C
J	ST/SOCKET TERMINUS	50	16-01	M83522/16-DNX	M29504/15-4171C
K	ST/BARE FIBER	50	16-01	M83522/16-DNX	N/A

4.2.6 Bare fiber adapters. Bare fiber adapters are required for connecting cables that do not have connectors installed to test equipment. A bare fiber adapter may have a MIL-C-83522 compatible connector on one end and a holding mechanism for stripped fiber on the other end or may be a temporary splice which mates the end of the fiber under test to the end of a equipment jumper cable.

4.3 Test procedures. The following paragraphs discuss test procedures in general terms only. Detailed, step-by-step procedures are presented in section 5.

4.3.1 Visual inspections. Visual inspections for mechanical damage are accomplished with the naked eye without using a magnifier.

4.3.2 Cable continuity test. The cable continuity test is a simple test to verify that there is no major damage to or breakage of a fiber. This test can be accomplished with any portable light source, such as a flashlight, or with the optical talk set.

4.3.3 Cable attenuation test. The cable attenuation test quantifies the attenuation of an optical signal over a particular cable length. The attenuation test is intended to be used for testing cables that have no terminations installed, or cables with terminations on only one end, and is performed using an OTDR.

4.3.4 Cable assembly link loss test. The cable assembly link loss test is used to measure the optical losses associated with connectors and splices in an optical link; and to demonstrate that the end-to-end attenuation of a cable assembly is within acceptable limits. The link loss test shall be performed using an optical power meter and stabilized light source, or an OLTS.

4.3.5 Cable topology end-to-end attenuation test. The cable topology end-to-end attenuation test is used to measure the optical loss over a series of concatenated optical links (see 3.3). Typically, this test is performed after interconnection of the fiber optic cable topology local and trunk cables, and measures the optical loss from one local cable equipment interface to the other. The end-to-end attenuation test shall be performed using an optical power meter and stabilized light source, or an OLTS.

4.4 Safety precautions. The following safety precautions apply:

a. Observe all written safety precautions given in the test procedures of this standard.

b. Observe all warning signs on equipment and all written safety precautions included in the equipment instruction manual.

c. The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an optical fiber communication system (OFCS) is inherently an eye safe system; but, when an optical fiber connection is broken and optical viewing instruments are used, it is possible that hazardous energy can enter the eye. For this reason four service group hazard classes have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition. Simplified definitions of the service groups are as follows.

SG1 - No risk when the end of a fiber is viewed with a microscope, eye-loupe or with the unaided eye. The total output power is less than 5 mW.

SG2 - Potentially hazardous when the end of the fiber is viewed for more than 0.25 seconds for a source that emits at wavelengths between 400 nm to 700 nm. (NOTE: This wavelength range is in the visible region and is outside of the either the 850 nm or 1300 nm wavelength ranges used in Navy equipment.)

SG3a - Hazardous when the end of the fiber is viewed with a microscope or eye-loupe, but is not hazardous when viewed with the unaided eye. The total output power of the source is between 5 mW and 50 mW. (NOTE: Most sources used in Navy systems or test equipment have output power significantly less than 5 mW.)

SG4a - Hazardous when the end of the fiber is viewed under any condition unless protective eye wear is worn. The total output power of the source is between 50 mW and 500 mW.

The following laser safety precautions shall apply:

(1) Ensure personnel are familiar with the laser degree of hazard and the required control measures.

(2) Light generated by light emitting diodes (LED's) and laser diodes may not be visible but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(3) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create a hazard due to its light gathering capability.

d. Safety glasses shall be worn when handling bare fibers. Always handle cable carefully to avoid personal injury. The ends of optical fibers may be extremely sharp and can lacerate or penetrate the skin or cause permanent eye damage if touched. If the fiber penetrates the skin, it most likely will break off, in which case the extraction of the fiber should be performed by trained medical personnel to prevent further complications.

e. Wash your hands after handling bare fibers or performing fiber terminations.

f. Observe all warning signs when handling solvents and epoxies. Become familiar with the first aid instructions for these agents.

5. DETAILED REQUIREMENTS

5.1 Acceptance tests. The acceptance tests shall be conducted on all components.

5.1.1 Cable. The tests to be performed on cables will be determined by the cable configurations as follows:

a. Visual inspection, Method 6A1 - all cables.

b. Cable attenuation test, Method 6B1 - cables greater than 50 m (165 feet) in length and either without connectors or splice ferrules installed, or with connectors or splice ferrules installed on only one end.

c. Cable assembly link loss test, Method 6C1 - cables with connectors or splice ferrules installed on both ends.

d. Cable continuity test, Method 6D1 - cables less than 50 m (165 feet) in length without connectors or splice ferrules installed on both ends.

5.1.2 Connectors, splices, and interconnection boxes. All components shall be subjected to the visual inspection of Method 6A1.

5.2 Pre-Installation tests. The pre-installation tests shall be performed just prior to installation of the components on the ship.

5.2.1 Cable. The tests to be performed will be determined by the cable configuration as follows:

a. Visual inspection, Method 6A1 - all cables.

b. Cable continuity test, Method 6D1 - all cables.

5.2.2 Connectors, splices, and interconnection boxes. All components shall be subjected to the visual inspection of Method 6A1.

5.3 Installation tests. The installation tests shall be performed as components are installed on the ship.

5.3.1 Cable. The installation tests will be performed in two phases, as follows:

a. Phase 1 - Immediately after the cable is installed in the cableways, repeat the visual inspection, Method 6A1, and the cable continuity test, Method 6D1, on all cables (terminated and unterminated).

b. Phase 2 - After installation of connectors or splices on the cable such that the cable is terminated on both ends, perform the cable assembly link loss test, Method 6C1.

5.3.2 Connectors, splices, and interconnection boxes. All components shall be subjected to the visual inspection of Method 6A1.

a. If required by the contracting activity, after installation of MIL-C-28876 connectors on the cable, perform the heavy duty connector mechanical pull test, Method 6G1.

5.4 Post-Installation tests. The post installation tests shall be performed on each link of the fiber optic cable topology after the link is configured, and shall consist of a visual inspection, Method 6A1 for cables and associated components, and a cable topology end-to-end attenuation test, Method 6E1.

5.5 Measurement quality jumper selection tests. Before placing measurement quality jumpers into use, they shall be tested in accordance with Method 6F1. The cables will be marked such that each cable can be readily identified as being a measurement quality jumper (see NAVSEA drawing 6877804).

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

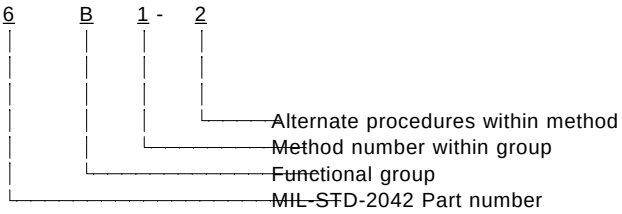
6.1 Intended use. The methods for testing depicted in this standard are intended to ensure the fiber optic cable topology is properly installed during and after each phase of installation procedures.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of DODISS must be cited in the solicitation (see 2.1.1).

6.3 Standard method designation. To simplify the usage of this standard, an alpha-numeric designation system was developed to identify and locate a given method. The methods were grouped together by function as follows:

Group A: Visual inspection.
B: Cable attenuation test.
C: Cable assembly link loss test.
D: Cable continuity test.
E: Cable topology end-to-end attenuation test.
F: Measurement quality jumper selection test

Then the designation system was completed as follows:



Thus, method 6B1-2 identifies the second alternate procedure within method 1 of group B in Part 6 (MIL-STD-2042-6) of MIL-STD-2042.

6.4 Subject term (key word) listing.

Acceptance tests
Pre-installation tests
Installation tests
Post-installation tests
Visual inspections
Continuity test
Attenuation test
Assembly link loss test
End-to-end attenuation test
Safety procedures
Measurement quality jumpers

Preparing activity:
NAVY - SH
(Project GDRQ-NXXX)

METHOD 6A1

VISUAL INSPECTION OF FIBER OPTIC COMPONENTS

1. SCOPE.

1.1 Scope. This method describes a procedure for a visual inspection of fiber optic cables and associated fiber optic cable topology components.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 Safety glasses are required if bare fibers are present.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of fibers as they may be razor sharp. Wash your hands after handling bare fiber.

3.2 Procedure I. Cable inspection.

NOTE: During handling, the cable shall be protected from kinks, twists, crushing, and sharp bends. (More detailed handling procedures are given in Part 1 of this standard.)

Step 1 - Examine the cable documentation to ensure that the cable conforms to the requirements of MIL-C-85045. Record all of the cable information (including the manufacturer's cable identification number and any optical performance information) from the cable documentation. (Acceptance Test only)

Step 2 - Examine the cable for the following: (NOTE: For cable on a reel, examine that portion of the cable that can be seen without removing the cable from the reel.)

a. Damage - cuts, burnt areas, abrasions, holes, roughened areas, bulges, thin spots, kinks, or wrinkles.

b. Marking - As a minimum, the part number, manufacturer's identification, the words "fiber optic cable", and a four-digit date code (Acceptance Test only).

c. Color code - OFCC jacket colorations should be easily discernable.

3.3 Procedure II. Connector, splice and interconnection box inspection.

Step 1 - Examine the documentation to ensure that the components conform to the requirements of the applicable Military Specifications.

Step 2 - Examine the components for the following:

a. Damage - missing or loose parts, dents, cracks, chips, burrs, or peeling or chipping of the plating or finish.

b. Marking - As a minimum, the part number and manufacturer's identification (Acceptance Test only).

METHOD 6B1

CABLE ATTENUATION TEST

1. SCOPE.

1.1 Scope. This method describes procedures for performing the cable attenuation test on cables 50 m (165 feet) or greater in length and either without connectors or terminations of any type, or with connectors or other terminations installed on only one end.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of the fibers as they may be razor sharp. Wash your hands after handling fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure I. Cable and fiber preparation for test.

3.2.1 Applicability. This procedure is applicable when the cable is not terminated with connectors or splices on either end.

3.2.2 The equipment and materials in table 6B1-I shall be used to perform this procedure.

TABLE 6B1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Cable jacket stripping tool (NAVSEA DWG 6872811-8 or equal)	1
Kevlar shears (NAVSEA DWG 6872811-16 or equal)	1
Wipes (NAVSEA DWG 6872811-18 or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air or compressed air	As required
Ruler	1
OFCC strip tool (NAVSEA DWG 6872811-10 or equal)	1
Safety glasses	1
Buffer strip tool (NAVSEA DWG 6872811-9 equal)	1
Cleaver (NAVSEA DWG 6872811-7 or equal)	1

NOTE: During handling, the cable shall be protected from kinks, twists, crushing, and sharp bends. (See Part 1 of this standard for more detailed cable handling procedures.)

Step 1 - Select one end of the cable.

Step 2 - Using the cable stripper, remove approximately 305 mm (12 inches) of the outer jacket from the unterminated end of the cable.

CAUTION: Do not cut or nick OFCC jackets.

Using the kevlar shears, carefully cut off the kevlar strength members, the exposed central member and any fillers.

Step 3 - Remove any water blocking material, clean the OFCC's with a wipe dampened with alcohol and blow them dry with air.

Step 4 - Measure and mark the OFCC cable jacket approximately 50 mm (2 inches) from the end of the fiber. Using the OFCC stripper, remove the OFCC jacket back to the mark.

Step 5 - Separate the kevlar strands from the buffered fiber and trim the strands back to the OFCC jacket end using the kevlar shears.

Step 6 - Measure and mark the buffer approximately 25 mm (1 inch) from the end of the fiber.

WARNING: Wear safety glasses when removing the buffer and coating to avoid possible eye injury.

Using the buffer stripper, remove the buffer and coating back to the mark. Remove the buffer and coating in small sections (approximately 6 mm (0.25 inch)) at a time. (NOTE: Normally, the buffer and coating are tightly adhered to one another and come off of the fiber at the same time.)

Step 7 - Remove any residual fiber coating from the bare fiber with a wipe dampened with alcohol. Wipe only once from the end of the buffer towards the end of the fiber.

Step 8 - Using one short light stroke with the cleaving tool, score the fiber approximately 12 mm (0.5 inch) from the end of the fiber. (NOTE: Do not break the fiber with the tool.) Pull off the fiber with a gentle straight pull. Deposit the waste fiber in a trash container.

Step 9 - Repeat steps 4 through 8 above for all of the OFCC's in the cable.

3.3 Procedure II. Method 6B1-1 Cable attenuation test for cables 50 m (165 feet) or greater in length.

3.3.1 The equipment and materials in table 6B1-II shall be used to perform this procedure.

TABLE 6B1-II. Equipment and materials.

DESCRIPTION	QUANTITY
Safety glasses	1
Test jumper cables (in accordance with Method 6F1 of this standard)	As required
Bare fiber adapters	As required
Calibration cable (known length greater than 100 meters)	1
Optical time domain reflectometer (OTDR) (NSN 7Z 6625 01 383 3789 or equal)	1
Alcohol bottle with alcohol/2-propanol	1
Wipes	As required
Canned air or compressed air	As required

NOTES:
1. These procedures were developed from EIA/TIA-455-61 (FOTP 61) "MEASUREMENT OF FIBER OR CABLE ATTENUATION USING AN OTDR."
2. Ensure the test equipment calibration is current.
3. Use a wipe dampened with alcohol to clean all adapters/connectors and blow them dry with air before making connections.

Step 1 - **WARNING:** Do not stare into the end of a fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

Following the OTDR manufacturer's instructions, energize the OTDR. If the cable group index is not known, proceed to step 2. If the cable group index is known, proceed to step 8.

Step 2 - Connect the calibration cable to the OTDR.

Step 3 - Enter the required parameters, except the cable group index, in accordance with the OTDR manufacturer's instructions.

Step 4 - Adjust and place the cursor at the beginning of the trace to obtain the distance coordinate z_1 (see figure 6B1-1).

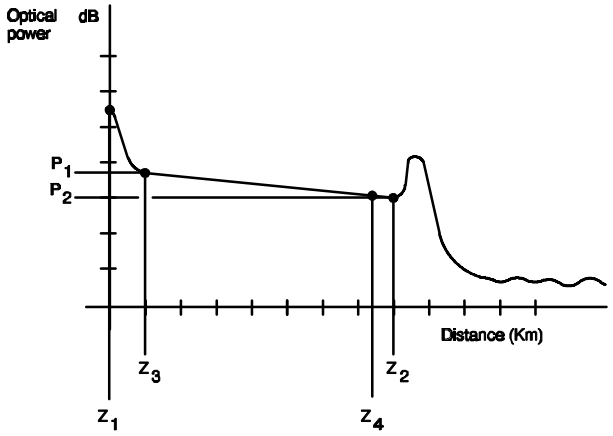


FIGURE 6B1-1. OTDR Display - (typical).

Step 5 - Place the second cursor at the end of the trace to obtain the distance coordinate z_2.

Step 6 - Adjust the group index scale until the difference (z_2-z_1) equals the length of the calibration cable.

Step 7 - Disconnect the calibration cable from the OTDR.

Step 8 - Select one end of the cable under test. (NOTE: If the cable is terminated on one end, select that end.)

Step 9 - Select the applicable jumper cable configuration (see table I in this part of this standard) from table 6B1-III. Connect the cable under test to the OTDR using the applicable view on figure 6B1-2.

TABLE 6B1-III. Test jumpers and adapters.

TERMINATION TO BE CONNECTED TO OTDR	REQUIRED JUMPER CONFIGURATION	APPLICABLE VIEW FIGURE 6B1-2
Bare fibers	K	1
M83522	G	2
M24623	H	3
M28876 4 CH PLUG	J	4
M28876 4 CH RECEPT	I	4
M28876 8 CH PLUG	J	4
M28876 8 CH RECEPT	I	4

Step 10 - Enter the required parameters in accordance with the OTDR manufacturer's instructions.

Step 11 - Adjust and place the cursor at the beginning (z_1) and the end (z_2) of the trace for the cable under test (see figure 6B1-3). Record the cable length (z_2 - z_1) and confirm that the measured length matches the length of the cable under test.

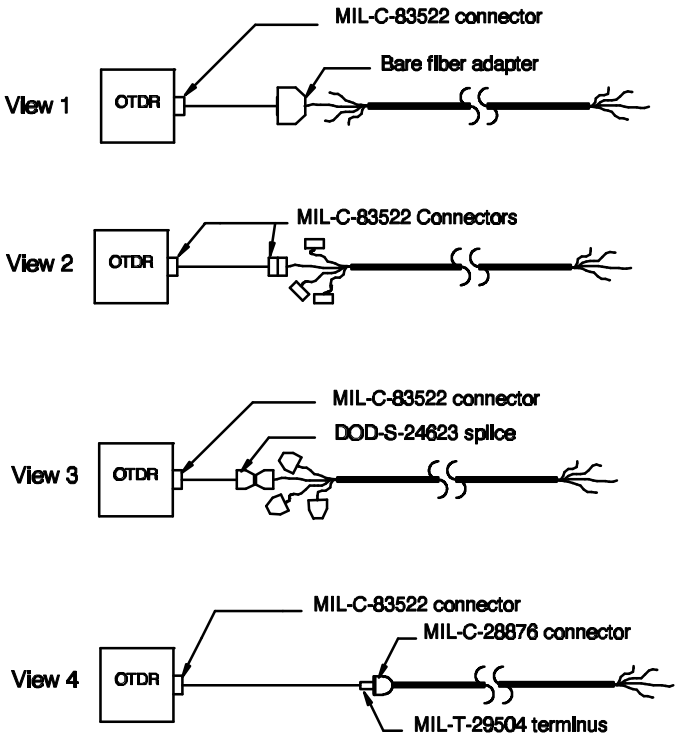


FIGURE 6B1-2. Test setup variations.

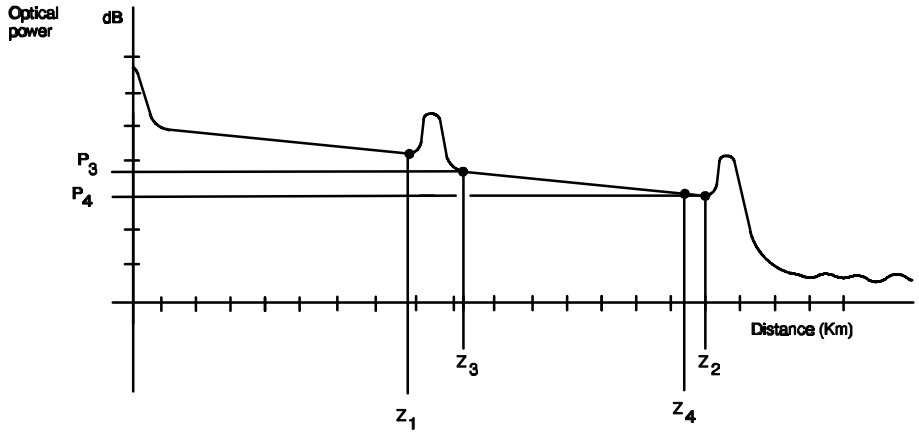


FIGURE 6B1-3. OTDR Display - (typical).

Step 12 - Adjust and place the cursor at the beginning (z_3) and end (z_4) of the linear portion of the trace for the cable under test (see figure 6B1-3). Record the cable attenuation in dB. The OTDR may automatically calculate the cable attenuation. If it does not, calculate the attenuation (B) in dB/km using the following equation:

Step 13 - Repeat steps 11 and 12 above for all the fibers in the cable.

$$B = \frac{P_3 - P_4}{z_4 - z_3}$$

Step 14 - The cable is considered satisfactory if the maximum measured attenuation for each fiber does not exceed the vendor's attenuation data by greater than 1 dB/km, or the maximum allowable attenuation specified in MIL-C-85045. (NOTE: If the maximum measured attenuation for a fiber exceeds the above values, the cable may have been damaged.)

Step 15 - If the cable is not going to be installed in a cableway within 48 hours, end seal the cable in accordance with Method 1A1 in Part 1 of this standard.

METHOD 6C1

CABLE ASSEMBLY LINK LOSS TEST

1. SCOPE.

1.1 Scope. This method describes procedures for performing a cable assembly link loss test on cables that have connectors or other terminations installed on both ends.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the end of the fibers as they may be razor sharp. Wash your hands after handling fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure I. Cable assembly preparation for test. This procedure is performed in series with Procedure II. Refer to section 3.3 to determine when this procedure is to be applied. Cable assemblies terminated in connectors do not require the performance of this procedure. Cable assemblies terminated in splice ferrules require the completion of a temporary splice in order to test for link loss. The splice procedures herein are abbreviated; a more detailed description is given in Method 2D1 in Part 2 of this standard.

3.2.1 The equipment and materials in table 6C1-I shall be used to perform this procedure.

TABLE 6C1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Alignment clip tool (NAVSEA DWG 6872812-1 or equal)	1
Splice alignment sleeve	As required
Index matching gel (MIL-M-24794)	As required
Splice alignment tool (NAVSEA DWG 6872812-5 or equal)	1

NOTES: 1. During handling, the cable shall be protected from kinks, twists, crushing and sharp bends. See Part 1 of this standard for more detailed cable handling procedures.

Step 1 - Mix a small portion of the index matching gel on a clean surface according to the manufacturer's instructions provided (vacuuming is not required).

NOTE: The index matching gel provided may be a one part gel that does not require mixing.

Step 2 - **CAUTION:** Opening the sleeve too much may damage the sleeve.

Adjust the splice alignment clip tool so that it opens the splice alignment clip just enough to insert the splice ferrules. Insert the tool tip into the alignment sleeve slot. Open the sleeve (see figure 6C1-1).

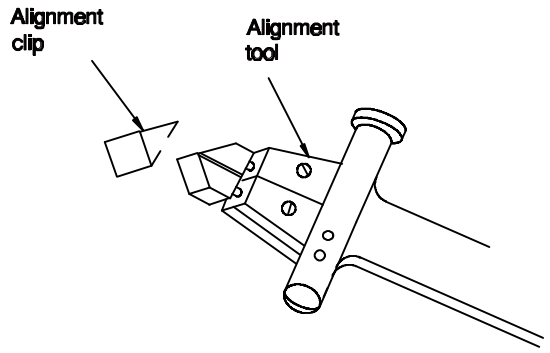


FIGURE 6C1-1. Opening the alignment sleeve.

Step 3 - Dip one of the polished ferrule tips into the gel and slide the ferrule into the alignment clip until the tip is approximately centered in the clip (see figure 6C1-2).

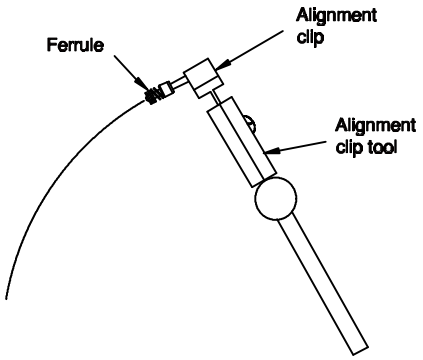


FIGURE 6C1-2. Inserting the ferrule into the alignment sleeve.

Step 4 - Dip the other ferrule tip into the index matching gel and slide the ferrule tip into the other side of the alignment clip (see figure 6C1-3). Ensure that the ferrule tips are centered in the alignment clip and the alignment tabs are facing the clip gap. Remove the alignment clip tool from the alignment clip. Verify that the ferrule tips are in contact by pushing the ferrules together.

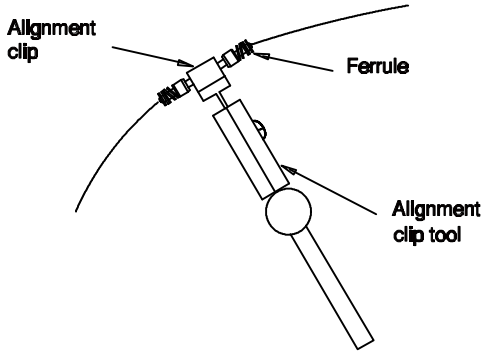


FIGURE 6C1-3. Inserting the second ferrule into the alignment sleeve.

Step 5 - Passive alignment - verify the tab alignment by inserting the splice assembly into the splice alignment tool making sure the tabs fit into the tool slots (see figure 6C1-4). If necessary, rotate either ferrule slightly to align the tabs. Remove the splice from the tool.

3.3 Procedure II. Method 6C1-1 power meter cable assembly link loss test.

3.3.1 The equipment and materials in table 6C1-II shall be used to perform this procedure.

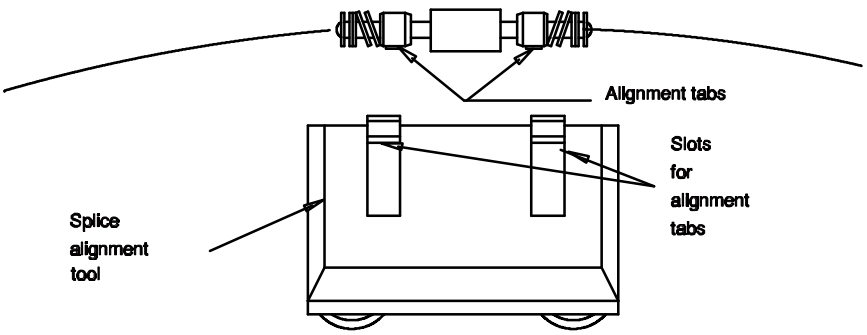


FIGURE 6C1-4. Aligning the tabs.

TABLE 6C1-II. Equipment and materials.

DESCRIPTION	QUANTITY
Wipes (NAVSEA DWG 6872811-18 or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air or compressed air	As required
Test reference cable (in accordance with Method 6F1 of this standard)	1
Test jumper cables (in accordance with Method 6F1 of this standard)	As required
Light source (NSN 7Z 6625 01 304 1739 or equal)	1
Power meter (NSN 7Z 6625 01 304 1739 or equal)	1
Protective caps (plastic)	As required
End seals (in accordance with part 1 of this standard)	As required

NOTES: 1. Ensure the test equipment calibration is current.

2. Use a wipe dampened with alcohol to clean the adapters/connectors and blow them dry with air before making the connections.

3. Make sure that both the light source and power meter have been energized long enough to have stable performance before making measurements.

Step 1 - Record the length of the cable from the vendor's data or as measured.

Step 2 - **WARNING:** Do not stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

Connect the test reference cable (configuration A in table I in this part of this standard) between the light source and the power meter and record the power (in dBm) at the meter (P_1) (see figure 6C1-5).

NOTE: The time delay between the measurement of P_1 and P_2 shall be kept to a minimum to prevent inaccurate measurements.

Step 3 - **CAUTION:** Make sure that the keys are correctly aligned to the mating keyways before mating jumper cables to MIL-C-28876 test cables. Incorrect keyway alignment will result in damage to the connector pins.

Select the applicable jumper cable configurations (see table I in this part of this standard) from table 6C1-III, and connect the test cable to the light source and the power meter as shown in the applicable

view of figure 6C1-6. For cable assemblies terminated in splice ferrules use Procedure I to assemble the cable assembly splice ferrules to the jumper cable splice ferrules.

Note: For cables with single terminus connectors, the reference cable should be used as J_1

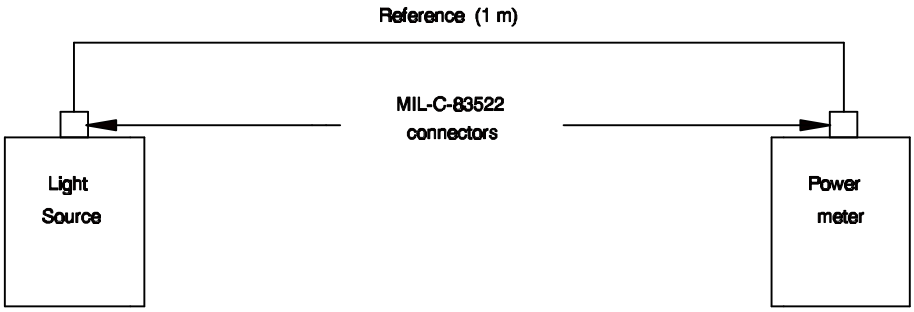


FIGURE 6C1-5. Connecting the reference cable.

TABLE 6C1-III. Test jumper configurations.

TERMINATION AT LIGHT SOURCE END	SOURCE JUMPER (J_1) CONFIGURATION	TERMINATION AT POWER METER END	POWER METER JUMPER (J_2) CONFIGURATION	VIEW FIG. 6C1-5
M83522	A	M83522	A	1
M83522	A	M24623	B	2
M83522	A	M28876 4 CH PLUG (RECEPT)	C (D)	3
M83522	A	M28876 8 CH PLUG (RECEPT)	E (F)	
M24623	B	M83522	A	4
M24623	B	M24623	B	5
M24623	B	M28876 4 CH PLUG (RECEPT)	C (D)	6
M24623	B	M28876 8 CH PLUG (RECEPT)	E (F)	
M28876 4 CH PLUG (RECEPT)	C (D)	M83522	A	7
M28876 4 CH PLUG (RECEPT)	C (D)	M24623	B	8
M28876 4 CH PLUG (RECEPT)	C (D)	M28876 4 CH PLUG (RECEPT)	C (D)	9
M28876 8 CH PLUG (RECEPT)	E (F)	M83522	A	7
M28876 8 CH PLUG (RECEPT)	E (F)	M24623	B	8
M28876 8 CH PLUG (RECEPT)	E (F)	M28876 8 CH PLUG	E (F)	9

Step 4 - Record the power (in dBm) at the meter (P_2).

Step 5 - Calculate the cable assembly link loss using the following formula and record the results:

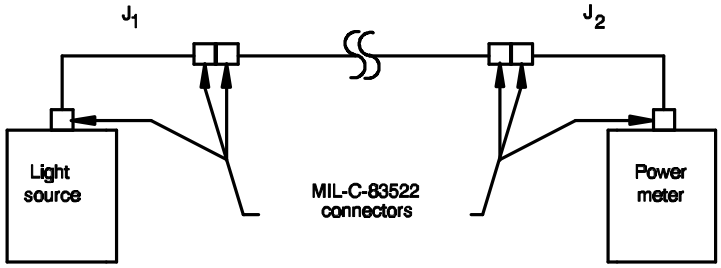
$$B_{CA} = (P_1 - P_2)$$

Where: B_{CA} = Total cable assembly link loss in dB
P_1 = Reference power in dBm
P_2 = Test power in dBm

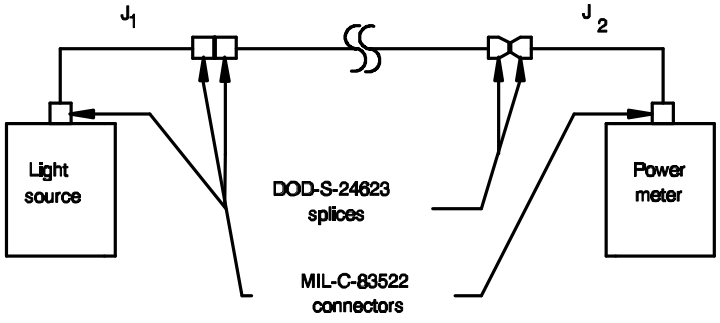
Step 6 - Repeat steps 2, 3, 4, and 5 for each fiber in the cable.

Step 7 - Repeat steps 2, 3, 4, 5, and 6 and remeasure the cable loss in the opposite direction.

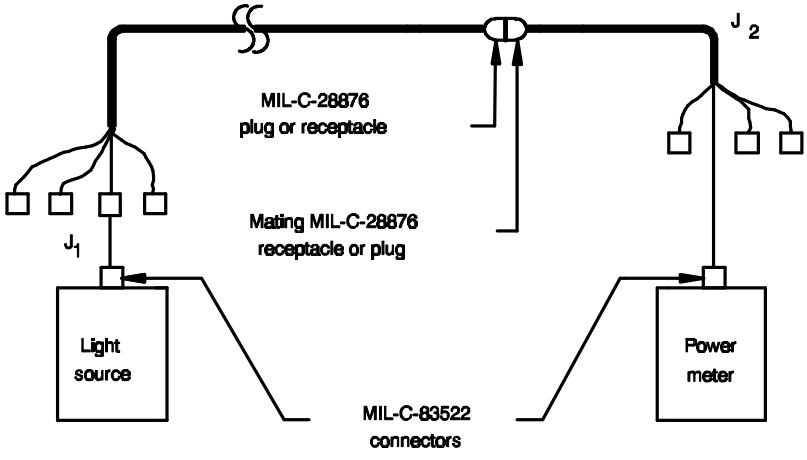
Step 8 - Identify the connectors/splices by type and proceed to 3.3.2 below.



View 1

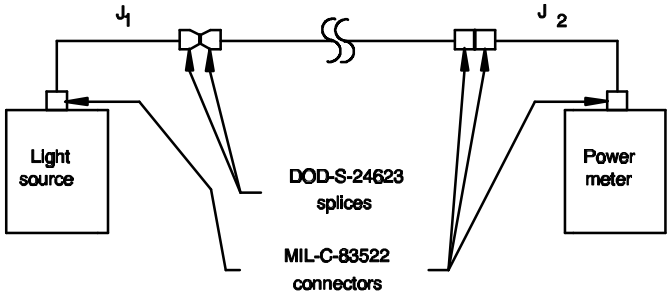


View 2

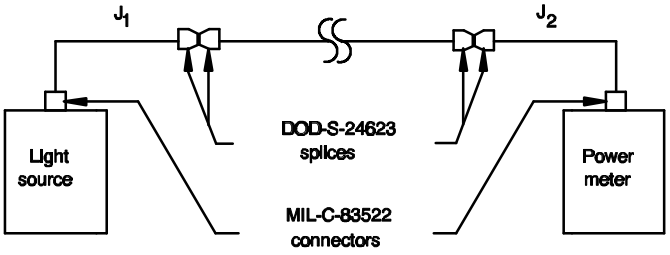


View 3

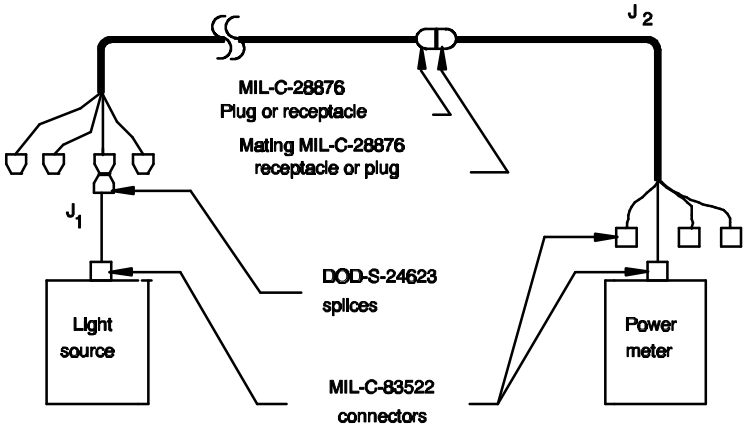
FIGURE 6C1-6. Test setup options.



View 4

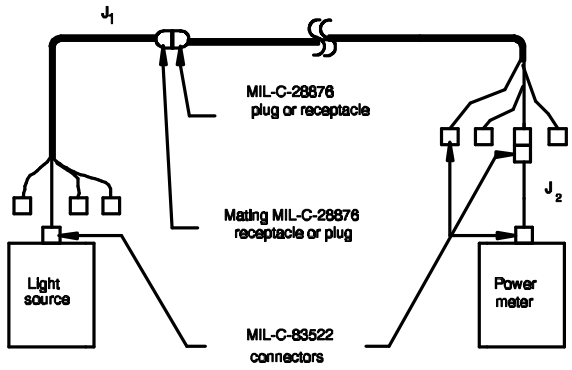


View 5

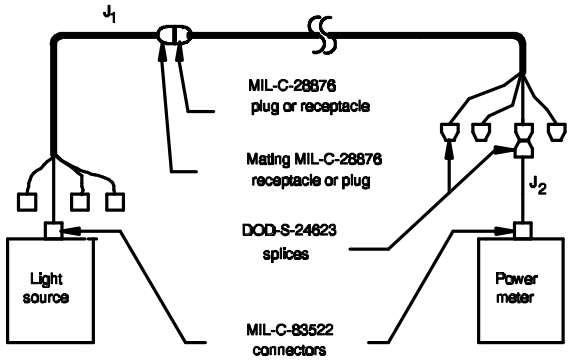


View 6

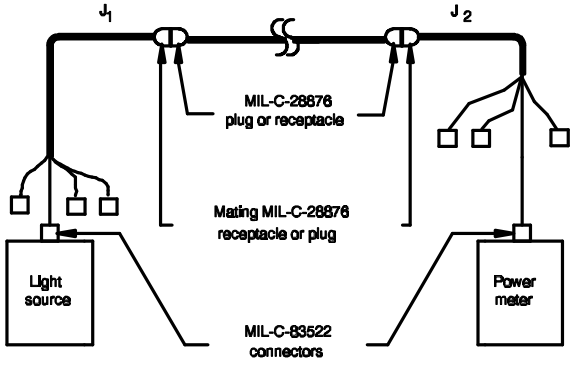
FIGURE 6C1-6. Test setup options - continued.



View 7



View 8



View 9

FIGURE 6C1-6. Test setup options - continued.

3.3.2 Calculations.

NOTE: If this test is part of an Acceptance Test, proceed to step 1 below. If this test is part of a Pre-Installation or Installation Test, proceed to step 2 below.

Step 1 - The cable assembly is considered satisfactory if the measured loss in each direction does not exceed the loss specified by the vendor for the cable assembly. If either measured loss is greater than the vendor specified loss, proceed to step 2 below.

Step 2 - Compare the measured loss in each direction to the maximum allowable loss. The maximum allowable loss is calculated from the maximum component loss values shown in table 6C1-IV using the following formula:

$$MAL = (A_{ca})\ (L)\ + \sum L_{co} + \sum L_{s}$$

Where: MAL = Maximum acceptable loss
A_{ca} = Maximum attenuation of the cable
L = Length of the cable
L_s = Maximum loss of a splice
L_{co} = Maximum loss of a connector

The cable assembly is considered acceptable if the measured loss in each direction is equal to or less than the maximum acceptable loss. If the measured loss in both directions is acceptable, proceed to step 4 below. If measured loss in either direction is greater than the maximum acceptable loss, proceed to step 3 below.

TABLE 6C1-IV. Maximum component loss values.

Component	Single mode	Multimode
Cable	1.0 dB/km	2.0 dB/km
Single terminus (light duty) connector	1.0 dB	1.0 dB
Multiple terminus (heavy duty) connector	1.0 dB	1.0 dB
Mechanical splice	0.2 dB tuned 0.6 dB untuned	0.2 dB tuned 0.6 dB untuned

Step 3 - If the measured loss in either direction is 0.5 dB or more above the maximum acceptable loss, reject the cable assembly. If the measured loss in either direction is less than 0.5 dB above the maximum acceptable loss, disconnect and clean all the connections and retest. If the loss in either direction is still unacceptable, reterminate or replace the defective components.

Step 4 - If the cable is not going to be installed in a cableway within 48 hours, install protective caps over the connectors or splices or end seal in accordance with Method 1A1 in Part 1 of this standard.

METHOD 6D1

CABLE CONTINUITY TEST

1. SCOPE.

1.1 Scope. This method describes a procedure for performing a cable continuity test on cables with or without connectors or terminations of any type.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 6D1-I shall be used to perform this procedure.

TABLE 6D1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Safety glasses	1
Optical intercom	1
Alcohol bottle with alcohol/2-propanol	As required
Wipes	As required
Canned air or compressed air	As required
Flashlight	1

3. PROCEDURE.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the ends of the fibers as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

Step 1 - Establish communications, if required, using the optical intercom or other available communication equipment.

Step 2 - Using a wipe dampened with alcohol, clean the fibers on both ends of the cable and blow them dry with air.

Step 3 - Using a flashlight or equivalent, shine light in each fiber and verify that light is present at the opposite end.

METHOD 6E1

CABLE TOPOLOGY END-TO-END ATTENUATION TEST

1. SCOPE.

1.1 Scope. This method describes a procedure for performing a cable topology end-to-end attenuation test to ensure that the fiber optic cable topology losses are within acceptable limits.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the end of the fibers as they are razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure I. Cable topology preparation for test. This procedure is performed in series with Procedure II. Refer to section 3.3 to determine when this procedure is to be applied. Cable topology links terminated in connectors do not require the performance of Procedure I. Cable topology links terminated in splice ferrules require the completion of a temporary splice in order to test for cable topology end-to-end attenuation. The splice procedure description herein is abbreviated; a more detailed description is given in Method 2D1 in Part 2 of this standard.

3.2.1 The equipment and materials in table 6E1-I shall be used to perform this procedure.

TABLE 6E1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Splice alignment clip tool (NAVSEA DWG 6872812-1 or equal)	1
Splice alignment sleeve	As required
Index matching gel (MIL-M-24794)	As required
Splice alignment tool (NAVSEA DWG 6872812-5 or equal)	1

Step 1 - Mix a small portion of the index matching gel on a clean surface according to the manufacturer's instructions provided (vacuuming is not required).

NOTE: The index matching gel provided may be a one part gel that does not require mixing.

Step 2 - **CAUTION:** Opening the sleeve too much may damage the sleeve.

Adjust the splice alignment clip tool so that it opens the splice alignment clip just enough to insert the splice ferrules. Insert the tool tip into the alignment sleeve slot. Open the sleeve (see figure 6E1-1).

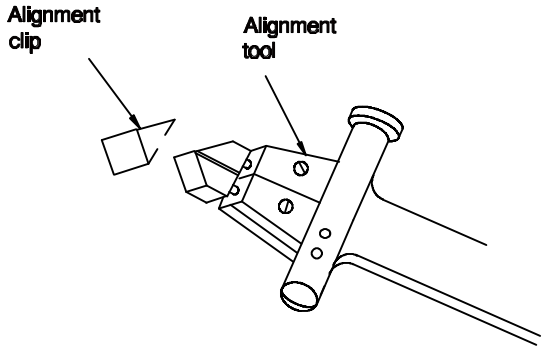


FIGURE 6E1-1. Opening the alignment sleeve.

Step 3 - Dip one of the polished ferrule tips into the gel and slide the ferrule into the alignment clip until the tip is approximately centered in the clip (see figure 6E1-2).

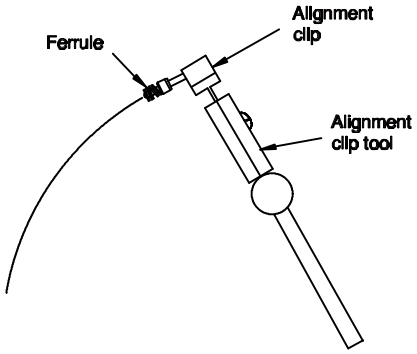


FIGURE 6E1-2. Inserting the ferrule into the alignment sleeve.

Step 4 - Dip the other ferrule tip into the index matching gel and slide the ferrule tip into the other side of the alignment clip (see figure 6E1-3). Ensure that the ferrule tips are centered in the alignment clip and the alignment tabs are facing the clip gap. Remove the alignment clip tool from the alignment clip. Verify that the ferrule tips are in contact by pushing the ferrules together.

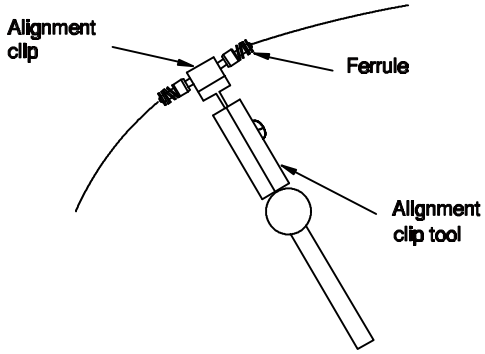


FIGURE 6E1-3. Inserting the second ferrule into the alignment sleeve.

Step 5 - Passive alignment - verify the tab alignment by inserting the splice assembly into the splice alignment tool making sure the tabs fit into the tool slots (see figure 6E1-4). If necessary, rotate either ferrule slightly to align the tabs. Remove the splice from the tool.

3.3 Procedure II. Method 6E1-1 cable topology end-to-end attenuation test.

3.3.1 The equipment and materials in table 6E1-II shall be used to perform this procedure.

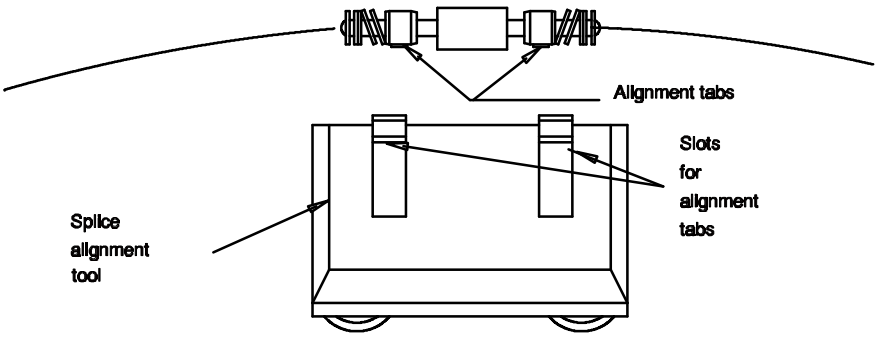


FIGURE 6E1-4. Aligning the tabs.

TABLE 6E1-II. Equipment and materials.

DESCRIPTION	QUANTITY
Wipes (NAVSEA DWG 6872811-18 or equal)	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air or compressed air	As required
Test reference cable (in accordance with Method 6F1 of this standard)	1
Test jumper cables (in accordance with Method 6F1 of this standard)	As required
Light source (NSN 7Z 6625 01 304 1739 or equal)	1
Power meter (NSN 7Z 6625 01 304 1739 or equal)	1
Protective caps (plastic)	As required
End seals (in accordance with part 1 of this standard)	As required

NOTES: 1. Ensure the test equipment calibration is current.

2. Use a wipe dampened with alcohol to clean the adapters/connectors and blow them dry with air before making the connections.

3. Make sure that both the light source and power meter have been energized long enough to have stable performance before making measurements.

Step 1 - **WARNING:** Do not stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

Connect the test reference cable (configuration A in table I in this part of this standard) between the light source and the power meter and record the power (in dBm) at the meter (P_1) (see figure 6E1-5).

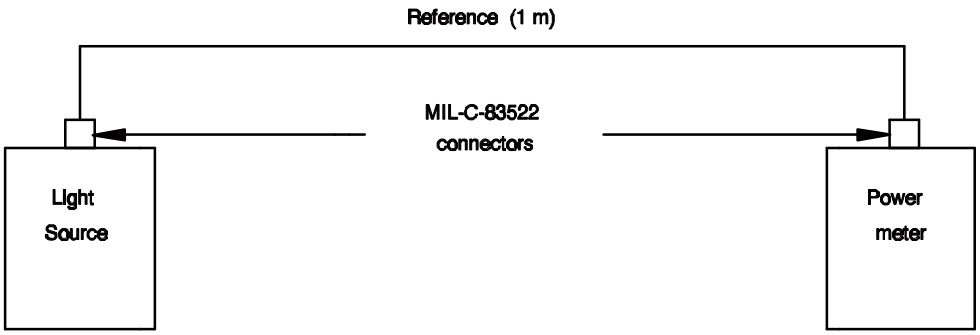


FIGURE 6E1-5. Connecting the reference cable.

NOTE: The time delay between the measurement of P_1 and P_2 shall be kept to a minimum to prevent inaccurate measurements.

Step 2 - **CAUTION:** Make sure that the keys are correctly aligned to the mating keyways before mating jumper cables to MIL-C-28876 test cables. Incorrect keyway alignment will result in damage to the connector pins.

Select the applicable jumper cable configurations (see table I in this part of this standard) from table 6E1-III, and connect the fiber optic topology link to the light source and the power meter as shown in the applicable view of figure 6E1-6. For cable topology links terminated in splice ferrules use Procedure I to assemble the cable topology link splice ferrules to the jumper cable splice ferrules.

NOTE: For cables with single terminus connectors, the reference cable should be used as J_1.

TABLE 6E1-III. Test jumper configurations.

TERMINATION AT LIGHT SOURCE END	SOURCE JUMPER (J_1) CONFIGURATION	TERMINATION AT POWER METER END	POWER METER JUMPER (J_2) CONFIGURATION	VIEW FIG. 6E1-5
M83522	A	M83522	A	1
M83522	A	M24623	B	2
M83522	A	M28876 4 CH PLUG (RECEPT)	C (D)	3
M83522	A	M28876 8 CH PLUG (RECEPT)	E (F)	
M24623	B	M83522	A	4
M24623	B	M24623	B	5
M24623	B	M28876 4 CH PLUG (RECEPT)	C (D)	6
M24623	B	M28876 8 CH PLUG (RECEPT)	E (F)	
M28876 4 CH PLUG (RECEPT)	C (D)	M83522	A	7
M28876 4 CH PLUG (RECEPT)	C (D)	M24623	B	8

TABLE 6C1-III. Test jumper configurations - continued.

TERMINATION AT LIGHT SOURCE END	SOURCE JUMPER (J_1) CONFIGURATION	TERMINATION AT POWER METER END	POWER METER JUMPER (J_2) CONFIGURATION	VIEW FIG. 6E1-5
M28876 4 CH PLUG (RECEPT)	C (D)	M28876 4 CH PLUG (RECEPT)	C (D)	9
M28876 8 CH PLUG (RECEPT)	E (F)	M83522	A	7
M28876 8 CH PLUG (RECEPT)	E (F)	M24623	B	8
M28876 8 CH PLUG (RECEPT)	E (F)	M28876 8 CH PLUG	E (F)	9

Step 4 - Record the power (in dBm) at the meter (P_2).

Step 5 - Calculate the cable topology end-to-end attenuation using the following formula and record the results:

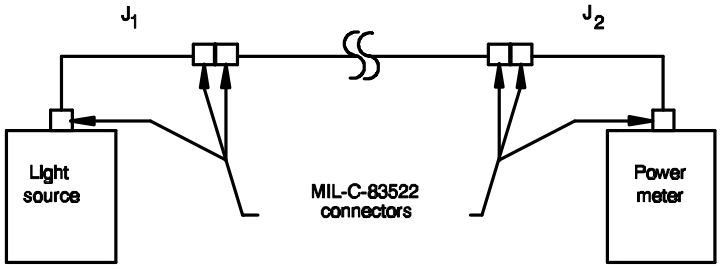
$$B_{TL} = (P_1 - P_2)$$

Where: B_{TL} = Total cable topology end-to-end attenuation in dB
P_1 = Reference power in dBm
P_2 = Test power in dBm

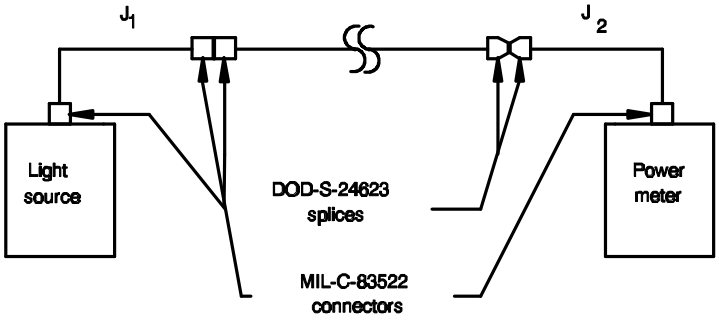
Step 6 - Repeat steps 2, 3, 4, and 5 for each fiber in the cable.

Step 7 - Repeat steps 2, 3, 4, 5, and 6 to measure the topology link in the opposite direction.

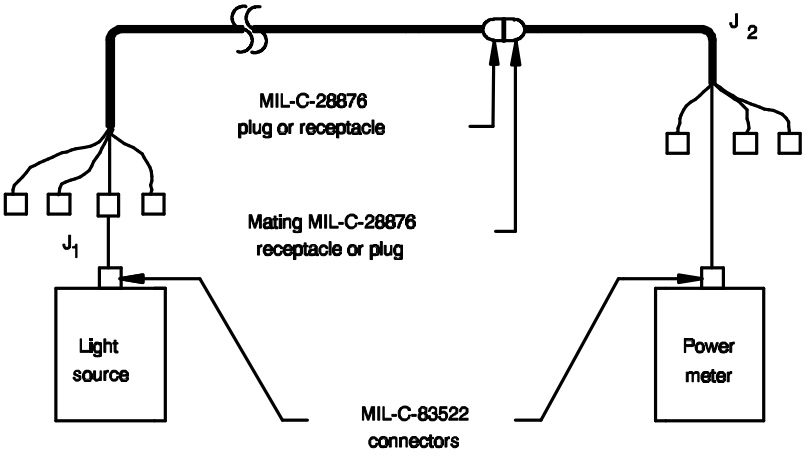
Step 8 - Identify the connectors/splices by type.



View 1

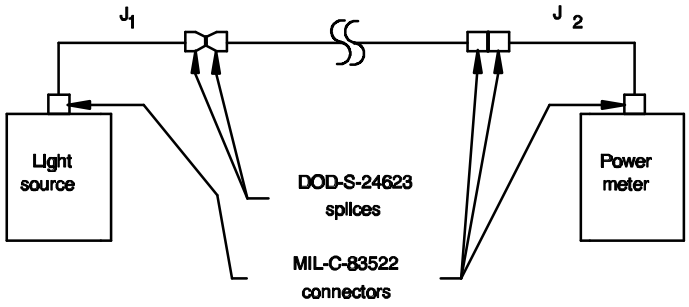


View 2

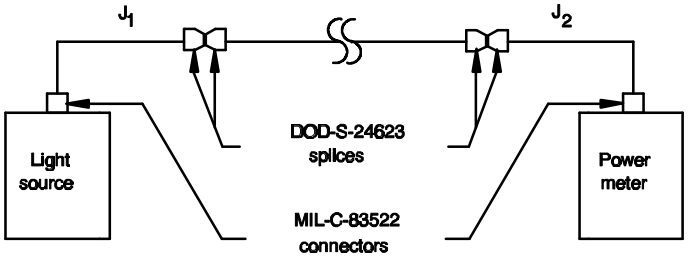


View 3

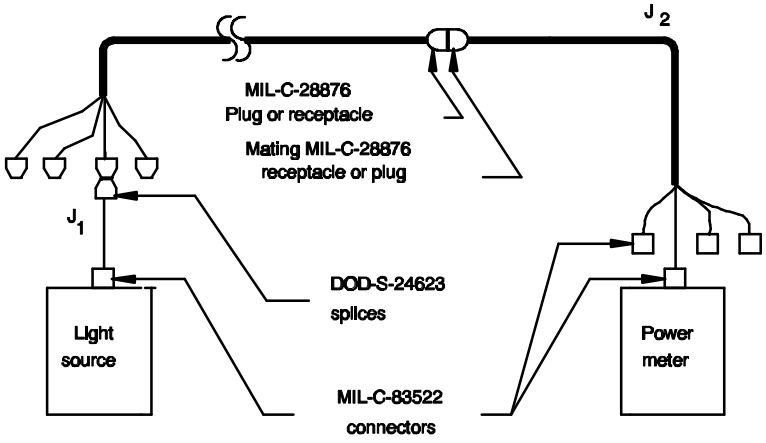
FIGURE 6E1-6. Test setup options.



View 4

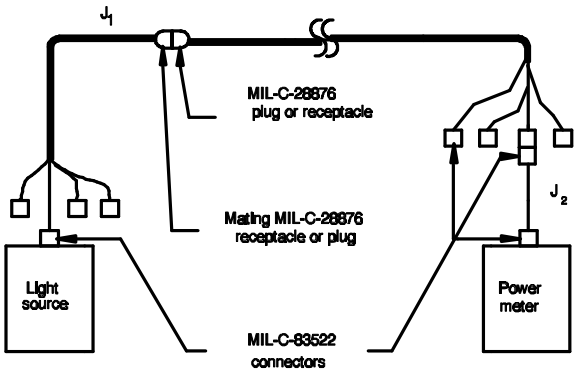


View 5

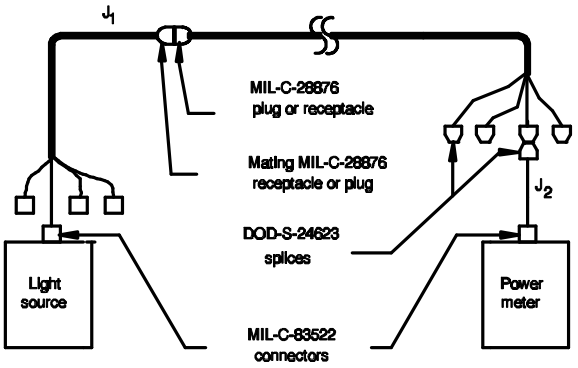


View 6

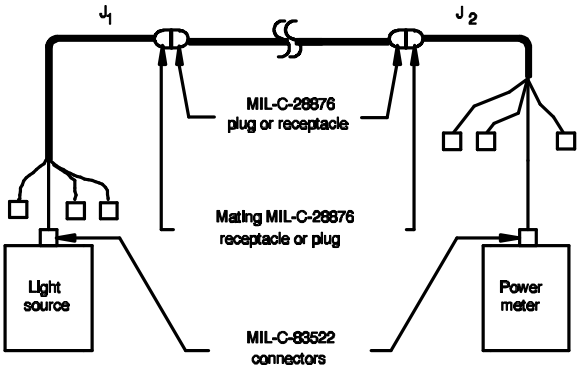
FIGURE 6E1-6. **Test setup options - continued.**



View 7



View 8



View 9

FIGURE 6E1-6. Test setup options - continued.

3.3.2 Calculations

Step 1 - Compare the measured end-to-end attenuation to the specified maximum allowable link loss. If the maximum allowable link loss is not specified, compare the measured end-to-end attenuation to the maximum allowable loss calculated from the maximum component loss values shown in table 6E1-IV using the following formula:

$$MAL = (A_{ca})\ (L)\ + \sum L_{co} + \sum L_{s}$$

Where: MAL = Maximum acceptable loss
A_{ca} = Maximum attenuation of the cable
L = Length of the cable
L_s = Maximum loss of a splice
L_{co} = Maximum loss of a connector

The cable topology link is considered acceptable if the measured end-to-end attenuation is equal to or less than the maximum acceptable loss. If the measured end-to-end attenuation is acceptable, proceed to step 3 below. If measured end-to-end attenuation is greater than the maximum acceptable loss, proceed to step 2 below.

TABLE 6E1-IV. Maximum component loss values.

Component	Single mode	Multimode
Cable	1.0 dB/km	2.0 dB/km
Single terminus (light duty) connector	1.0 dB	1.0 dB
Multiple terminus (heavy duty) connector	1.0 dB	1.0 dB
Mechanical splice	0.2 dB tuned 0.6 dB untuned	0.2 dB tuned 0.6 dB untuned

Step 2 - If the measured end-to-end attenuation is 1.0 dB or more above the maximum acceptable loss, reject the cable topology link. If the measured end-to-end attenuation is less than 1.0 dB above the maximum acceptable loss, disconnect and clean all of the connections and retest. If the end-to-end attenuation is still unacceptable, reterminate or replace the defective components.

Step 3 - If the cable topology link is not going to be immediately connected to equipment, install protective caps over the connectors or splices or end seal in accordance with Method 1A1 in Part 1 of this standard.

METHOD 6F1

MEASUREMENT QUALITY JUMPER CABLE SELECTION TEST

1. SCOPE.

1.1 Scope. This method describes procedures for performing a measurement quality jumper cable selection test on jumper cables that have connectors or other terminations installed on both ends.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in the tables located in the applicable sections of this method shall be used to perform these procedures.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Safety glasses shall be worn when handling bare fibers.

b. Do not touch the end of the fibers as they may be razor sharp. Wash your hands after handling bare fiber.

c. Observe warnings and cautions on equipment and materials.

d. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

3.2.1 The equipment and materials in table 6F1-I shall be used to perform this procedure.

TABLE 6F1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Wipes	As required
Alcohol bottle with alcohol/2-propanol	1
Canned air or compressed air	As required
Test reference cable (ST on both ends)	1
Test reference cable (ST to MIL-T-29504/14 pin terminus)	1
Test reference cable (ST to MIL-T-29504/15 socket terminus)	1
Test reference cable (ST to MIL-S-24623/4 splice ferrule)	1
Test jumper cable (ST on both ends with each end labeled A or B)	1
Test jumper cable (ST to socket terminus)	1
Test jumper cable (ST to pin terminus)	1
Test jumper cable (ST to splice ferrule)	1
Light source (NSN 7Z 6625 01 304 1739 or equal)	1
Power meter (NSN 7Z 6625 01 304 1739 or equal)	1
Protective caps (plastic)	As required
ST adapter (single mode)	1
MIL-C-28876 plug connector	1
MIL-C-28876 receptacle connector	1

TABLE 6F1-I. Equipment and materials - continued.

DESCRIPTION	QUANTITY
ST termination type power meter adapter	1
Single socket terminus power meter adapter	1
Single pin terminus power meter adapter	1
Splice ferrule termination type power meter adapter	1

NOTES: 1. Ensure the test equipment calibration is current.

2. Use a wipe dampened with alcohol to clean the adapters/connectors and blow them dry with air before making connections.

3. Identify and label all of the jumpers to be evaluated.

4. Reference quality jumper cables are cables constructed using fibers and connectors with tightened geometrical specifications (for example, diameter, concentricity). For more information on reference quality jumper cables, see EIA/TIA-455-171.

5. Make sure that both the light source and power meter have been energized long enough to have stable performance before making measurements.

Step 1 - Select a test jumper.

NOTE: The loss of the test jumper end with an ST connector is measured first. If both ends of the test jumper are terminated with ST connectors, the ends shall be identified as "A" and "B" and the loss of "A" measured first.

Step 2 - **WARNING:** Do not look into the end of a fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

Connect the ST to ST reference jumper between the light source and the power meter and record the power at the meter (P_1) (see figure 6F1-1). Disconnect the reference jumper from the power meter.

NOTES: 1. The time delay between the measurement of P_1 and P_2 shall be kept to a minimum to prevent inaccurate readings.

2. The reference jumper to light source connection shall not be disturbed between measurement of P_1 and P_2 to prevent inaccurate readings.

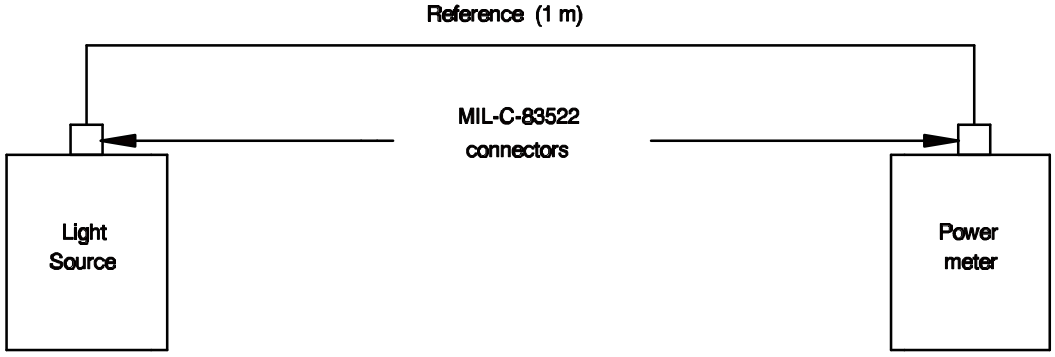


FIGURE 6F1-1. Connecting the reference cable.

Step 3 - Connect the test jumper to the reference jumper using a single-mode ST to ST adapter and to the power meter using the applicable power meter adapter head (see figure 6F1- 2).

Step 4 - Record the power at the meter (P_2).

Step 5 - Calculate the ST connector loss using the following formula:

Where: B_{ST} = ST connector loss in dB
P_1 = Reference power in dBm
P_2 = Test power in dBm

$$B_{ST} = (P_1 - P_2)$$

Step 6 - Record the ST connector loss along with the test jumper identification.

Step 7 - Repeat step 2 through step 6 ten times for the selected test jumper. Use a wipe dampened with alcohol to clean the adapters/connectors and blow them dry with air before making each connection.

NOTE: The loss of the second test jumper end is measured next. If both ends of the test jumper have ST connectors on them, the loss of the "B" end is measured next.

Step 8 - Connect the ST to ST, pin terminus, socket terminus, or MIL-S-24623 splice reference jumper between the light source and the power meter and record the power at the meter (P_1) (see figure 6F1-3). Disconnect the reference jumper from the power meter.

NOTES: 1. The time delay between the measurement of P_1 and P_2 shall be kept to a minimum to prevent inaccurate readings.

2. The reference jumper to light source connection shall not be disturbed between measurement of P_1 and P_2 to prevent inaccurate readings.

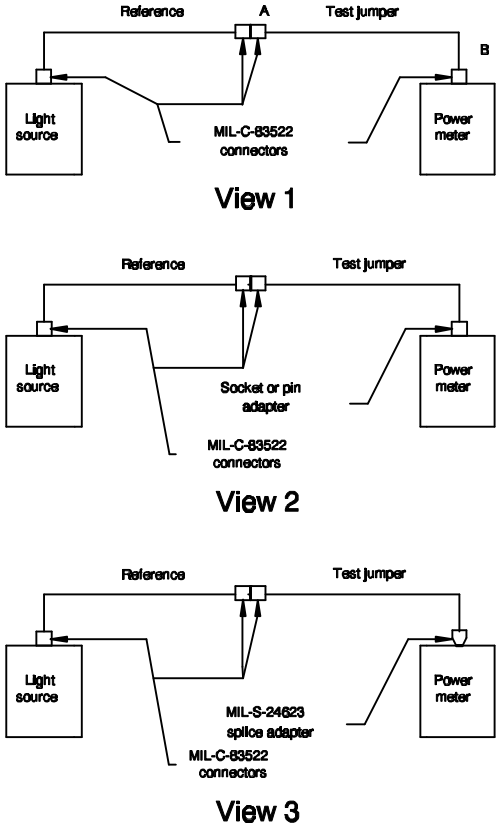


FIGURE 6F1-2. Measurement options.

Step 9 - Connect the test jumper to the reference jumper and to the power meter using the ST adapter head (see figure 6F1-4).

NOTES: 1. For either pin or socket termini, the termini shall be inserted into MIL-C-28876 plug or receptacle connectors and mated.

2. For MIL-S-24623 splices, the splice ferrules shall be mated using a splice alignment clip as specified in MIL-STD-2042-2.

Step 10 - Record the power at the meter (P_2).

Step 11 - Calculate the terminus or splice connection loss using following formula

$$B_C = (P_1 - P_2)$$

Where: B_C = Terminus or splice connection loss in dB
P_1 = Reference power in dBm
P_2 = Test power in dBm

Step 12 - Record the terminus or splice connection loss along with the test jumper identification.

Step 13 - Repeat step 8 through step 12 ten times for the selected test jumper. Use a wipe dampened with alcohol to clean the connectors/splices and blow them dry with air before making each connection.

3.3 Calculations.

Step 1 - Calculate the mean loss for each end of the test jumper using the following formula and record the results:

$$\mu_C = \frac{1}{10} x \sum_{n=1}^{10} B_{Cn}$$

Where: μ_C = Mean connection loss in dB
B_{cn} = Connection loss for measurement n in dB

Step 2 - Calculate the standard deviation of the measured loss for each test jumper end using the following formula and record the results:

$$\sigma_C = \sqrt{\frac{\sum_{n=1}^{10} (B_{Cn} - \mu_C)^2}{9}}$$

Where: σ_C = Standard deviation of the connection loss in dB

Step 3 - A test jumper is considered satisfactory if the mean loss and the standard deviation of the loss of each end is in accordance with Table 6F1-II.

NOTE: 1. For jumper cables which are in excess of 1 m in length, the loss of the fiber can be added to the following acceptable loss limits.

TABLE 6F1-II. Test jumper loss acceptance criteria.

End connection	Acceptable loss (dB)	Standard deviation (dB)
MIL-C-83522/16	$0.15 \leq B_{ST} \leq 0.35$	0.05 max
MIL-T-29504/14 pin terminus	$0.30 \leq B_C \leq 0.70$	0.05 max
MIL-T-29504/15 socket terminus	$0.30 \leq B_C \leq 0.70$	0.05 max
MIL-S-24623/4 splice	$0.10 \leq B_C \leq 0.30$	0.05 max

Step 4 - If the mean loss or the standard deviation of either end is not in accordance with Table 6F1-II, the jumper shall not be used for making optical loss measurements.

METHOD 6G1

HEAVY DUTY CONNECTOR MECHANICAL PULL TEST

1. SCOPE.

1.1 Scope. This method describes procedures for performing a mechanical pull test on the cable strain relief of heavy duty connectors. The performance of this method is required only when specified by the contracting activity.

2. REQUIRED EQUIPMENT AND MATERIALS.

2.1 The equipment and materials in table 6G1-I shall be used to perform this procedure.

TABLE 6G1-I. Equipment and materials.

DESCRIPTION	QUANTITY
Connector clamp	1
Cable pulling device	1
Strain gage (with accuracy of +/- 5 percent)	1

NOTE: The cable pulling device should not introduce any permanent deformation into the fiber optic cable jacket.

3. PROCEDURES.

3.1 Safety summary. The following safety precautions shall be observed:

a. Observe warnings and cautions on equipment and materials.

b. Never stare into the end of a fiber connected to a laser source or LED.

3.2 Procedure.

Step 1 - Attach the strain gage between a fixed object and the connector clamp.

Step 2 - Attach the heavy duty connector to the connector clamp.

Step 3 - Attach the cable pulling device to the fiber optic cable.

Step 4 - Pull on the cable assembly with a force of 444 Newtons (100 lbs) for one minute.

Step 5 - Disconnect the cable pulling device and the connector clamp from the cable assembly.

Step 6 - Visually inspect the connector/cable interface for cable pullout and deformation of the cable jacket. Cable assemblies which show these defects shall be rejected.